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Safety

Note: Spicer 10 Series™ Driveshafts are found on vehicles throughout the world. Therefore, this manual includes worldwide terminology.

General Safety

The following WARNINGS and CAUTIONS should be read and understood before attempting any service or repair on the various components of the driveshaft assembly.

Under no circumstances should individuals attempt to perform driveline service and/or maintenance procedures for which they have not been trained or do not have the proper tools or equipment.

Failure to take common sense, precautionary measures when working on a vehicle or other machinery could result in property damage, serious personal injury, or death. To avoid property damage, serious personal injury, or death, please follow basic safety rules as noted below.

1. **ALWAYS** wear safety glasses when performing maintenance or service. Failure to do so can result in personal injury and/or partial or complete vision loss.

2. **NEVER** perform service or maintenance tasks underneath a vehicle while the engine is running. Be sure the vehicle engine is off and the keys are removed from the ignition.

3. **NEVER** perform service or maintenance tasks underneath a vehicle that is not on a level or flat surface.

4. **NEVER** work on a driveshaft without blocking the vehicle wheels and releasing all parking brakes.

5. **ALWAYS** wear gloves when handling parts with sharp edges or abrasive surfaces.

6. **NEVER** lift a vehicle without the appropriate weight-rated vehicle-lift equipment. Always properly support the vehicle with appropriate weighted support equipment.

7. **NEVER** remove a driveshaft from a vehicle without keeping the transmission in neutral.

8. **ALWAYS** use support straps to prevent the driveshaft from falling out of the vehicle during the removal and installation process.

Note: This manual does not discuss the removal and installation of Spicer 10 Series™ Driveshaft assemblies from the vehicle. It only covers the disassembly and reassembly of component parts of the driveshaft assembly. Please refer to the original-equipment manufacturer’s service documentation for removal and installation procedures.

9. **NEVER** heat components, and never use sledgehammers or floor jacks to remove the driveshaft from the vehicle.

Note: For driveshaft applications that have pillow blocks, dampers, parking brakes, or retarders, refer to these component manufacturers’ or the original equipment manufacturer’s service manuals for the proper procedures. NEVER perform any unauthorized procedures that will change the disconnected properties of Spicer products.

**Rotating Driveshafts**

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.
Component Safety

Driveline

Failure to replace damaged driveline components can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Reassembly of a driveline out of original phase can cause vibration and failure of the driveline and attaching components. Driveline failure can result in separation of the driveline from the vehicle, resulting in property damage, serious personal injury, or death.

Driveshaft assemblies can weigh in excess of 100 pounds (46 kilograms). Be sure to use proper lifting techniques when handling driveshafts. More than one person may be needed when handling driveshaft assemblies.

Never heat components, never use sledge hammers, and never use floor jacks to disassemble driveshafts. This can result in damaged, weakened, or bent components.

End Fitting

A loose end-fitting can result in driveline failure, which can in turn lead to separation of the driveline from the vehicle. A separated driveline can lead to property damage, serious personal injury, or death.

Universal Joint

Excessive looseness across the end of universal joint bearing cup assemblies can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline. A separated driveline can lead to property damage, serious personal injury, or death.

DO NOT reuse bolts or use inferior grade bolts. Reuse of bolts and/or use of inferior grade bolts can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Failure to torque bolts to specification can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Use a journal locator to avoid nicking journal cross trunnions or damaging oil seal slingers.

If a bearing assembly or journal cross is worn or damaged, the universal joint assembly must be replaced.

Be sure the snap rings are properly seated in the snap ring grooves.

Slip Member

Excessive radial looseness in the slip member assembly can cause imbalance or vibration in the driveshaft. Imbalance or vibration can cause components to wear, which in turn can result in separation of the driveline from the vehicle. A separated driveline can cause property damage, serious personal injury or death.

Yoke (Includes Slip Yoke, Yoke Shaft, and Tube Yoke)

A loose or damaged slip yoke seal allows contaminants to invade the slip member assembly. Invasion of contaminants into the slip member assembly can degrade the grease, and damage slip member components, which can result in driveline separation. A separated driveline can result in property damage, serious personal injury, or death.

DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can be a cause of cross and bearing failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Yoke shaft assemblies can weigh in excess of 50 pounds (23 kilograms). Be sure to use proper lifting techniques when handling yoke shafts.
Tubing

**WARNING**

Bent or dented tubing can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

**CAUTION**

Do not bend or dent the tube when handling or servicing driveshaft.

Midship Nut

**WARNING**

DO NOT reuse the midship nut. Reuse of the midship nut can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

DO NOT touch or disturb the micro-encapsulated adhesive found on the midship nut threads. Doing so may initiate the curing process and impair the installation of the nut. Premature curing of the micro-encapsulated adhesive will result in the improper installation of the midship nut. Improper installation of this nut can cause driveline failure, which can result in a separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Failure to torque the midship nut to required specifications can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A loose midship nut can result in driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Center Bearing

**WARNING**

Loose center bearing bracket bolts can result in driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Damaged center bearings or center bearing components can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Foreign Material

**WARNING**

Build-up of foreign material, excessive paint, or undercoating on a driveshaft can cause imbalance or vibration in the driveshaft assembly. Imbalance or vibration can cause component wear, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A contaminated slip member can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Hardware

**WARNING**

Loose, missing, or damaged bearing retainers or stamped straps, retaining bolts, nuts, end fitting tangs, snap rings, or rotating bearing cups can result in driveline failure. A separated driveline can lead to property damage, serious personal injury, or death.

DO NOT reuse bolts, straps, nuts, or damaged bearing retainers, or use inferior grade bolts. Reuse of bolts, straps, nuts, or damaged bearing retainers, or use of inferior grade bolts, can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

**CAUTION**

If loosening or removing bolts, always install a new strap and bolts and torque bolts to specification.
Lubrication (When Applicable)

A missing, loose, or fractured grease zerk (nipple) fitting or plug eliminates the ability to lubricate the universal joint. Improper or inadequate lubrication can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Improper lubrication techniques can cause driveline failure, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

A missing, loose, damaged, or fractured plug or grease zerk (nipple) fitting can allow contaminants to invade the universal joint. Invasion of contaminants into the universal joint can degrade grease and cause universal joint damage, which can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Incompatible greases that are applied to universal joints and/or slip members can result in driveline failure and can result in separation of the driveline from the vehicle. A separated driveline can result in property damage, serious personal injury, or death.

Hand tightening of grease zerk (nipple) fittings or plugs is NOT recommended. Failure to torque grease zerk (nipple) fittings to specifications can result in separation of the driveline from the vehicle. A separated driveline can cause property damage, serious personal injury, or death.

In cold temperatures, be sure to drive the vehicle immediately after lubrication. This activates the slip spline and removes excess grease. Failure to do so could cause excess grease to stiffen in the cold weather and force the plug out. The end of the spline would then be open to collect contaminants and cause the spline to wear and/or seize.

All slip yoke and universal joint seals should be completely purged.
Inspection

Spicer 10 Series™ Driveshafts should be carefully inspected at recommended original-equipment manufacturer's service intervals and/or at Spicer recommended lubrication intervals as shown in the Lubrication section on page 11.

End Fitting Inspection

This information refers to axle, transmission, transfer case, and center bearing end fittings. Please refer to the End Fitting information in Component Safety on page 2.

1. Visually inspect all end-fitting retaining nuts or bolts for any gaps or looseness between mating surfaces. If gaps are present, consult transmission, axle, or transfer case original-equipment manufacturer's service and maintenance manual for proper fastener specifications. If looseness is evident between the nut, yoke, or center bearing, take the driveshaft to a qualified driveshaft facility for further inspection and repair.

2. Check all end fittings for looseness. Grasp the end fitting with both hands and try to move it vertically and horizontally to feel any looseness.

3. Grasp the end fitting with both hands and rotate left to right, feeling for play and backlash. There should not be any movement in the end fittings relative to the output or input shafts to which they are connected. If looseness is evident, consult transmission, axle, or transfer case original-equipment manufacturer's service and maintenance manuals for proper end fitting to shaft specifications.

4. Visually inspect for:
   - damaged half round bearing straps
   - loose bearing strap bolts
   - loose companion flange bolts and nuts
   - damaged or worn tangs on end fittings
   - damaged or missing snap rings
   - rotating bearing cups

If any of these conditions are present, component replacement is necessary. Refer to the original-equipment manufacturer's recommendations for removal instructions.
Bearing Plate (Full Round) Yoke Inspection

Please refer to the End Fitting information in the Component Safety section on page 2.

1. Refer to original-equipment manufacturer for removal of the driveshaft from the vehicle.

2. Place the driveshaft in v-blocks to remove the cross and bearing assemblies. Completely remove the cross and bearings from the yokes at both ends of the driveshaft using a universal joint removal tool. Next, disassemble the bearing assemblies from the slip yoke (and flange yoke, where applicable), using a tool kit.

3. Clean the cross holes on the yoke, and inspect the cross hole surfaces for damage or raised metal. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.

4. Check the yoke lug cross holes with a No-Go Wear Gauge, and then use a Spicer Alignment Bar to inspect for damage by sliding through both cross holes simultaneously.

The alignment bar will identify yoke lugs that have taken a set because of excessive torque. The raised metal or distorted lugs can be a cause of premature cross and bearing problems.

5. If, after proper cleaning of the cross holes, the alignment bar will not pass through both cross holes simultaneously, the yoke lugs are distorted, and the yoke or yokes should be replaced.

WARNING

DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can cause cross and bearing failure, which can result in separation of the driveline from the vehicle.
Quick Disconnect™ (Half Round) End Yoke Inspection
Please refer to the End Fitting information in the Component Safety section on page 2.

1. Remove the universal joint assembly from the end yoke, and clean the cross hole surfaces for inspection.

2. Inspect the cross hole surfaces for damaged or raised metal. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.

DO NOT deform yoke cross holes by removing excessive metal. Raised metal or deformed yoke cross holes can cause cross and bearing failure, which can result in separation of the driveline from the vehicle.

   Inspect the bearing caps for any indication of rotation within the cross holes. If rotation is apparent, the yoke should be replaced.

3. Check the yoke for cross hole alignment using the Spicer alignment gauge. Place the correct bushing in each lug ear, allowing a .030" (.75 mm) to .060" (1.5 mm) clearance between the tang and the bushing.

4. Assemble bearing straps and bolts, tightening bolts a minimum of 30 lbs. ft. (41 N•m). Insert the alignment bar into one bushing. If the bar enters and passes through the opposite bushing, alignment is correct. If the alignment bar will not enter the opposite bushing, re-inspect for yoke seat burrs.

5. If, after proper cleaning, the alignment bar still does not pass through both bushings, the yoke lugs are distorted, and the yoke should be replaced.
Universal Joint Inspection

Please refer to the Universal Joint information in the Component Safety section on page 2.

1. Check for excessive looseness between the ends of the universal joint bearing cup assemblies and trunnions.

2. Grasp the inboard yoke on the driveshaft with both hands and attempt to move the yoke horizontally and vertically. There should be less than .006” (.15 mm) movement in the universal joint relative to the inboard or outboard yokes. If looseness is greater than .006” (.15 mm) in either direction, the universal joint must be replaced. See Disassembly and Reassembly on page 16.

Re-lubable Style Universal Joints

1. With re-lubable style universal joints, check for the presence of all grease zerk (nipple) fittings. Grease zerk (nipple) fittings should not be missing, loose, or fractured.

2. If a grease zerk (nipple) fitting is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.

3. If a grease zerk (nipple) fitting is fractured or missing, the entire universal joint must be replaced. Refer to Disassembly and Reassembly on page 16 for removal and replacement instructions.

Permanently Greased Plug Style Universal Joints

Please refer to the Universal Joint information in Component Safety on page 2.

1. Permanently greased plug style universal joints have a plug rather than grease zerk (nipple) fittings. Make sure the plug is not missing, loose, or fractured. If the plug is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.

2. If a plug is missing or fractured, the entire universal joint must be replaced. Refer to recommendations in the Disassembly and Reassembly on page 16 for removal and replacement instructions.
Slip Member Assembly

This information refers to slip yokes and tube shaft assemblies. Please refer to the Slip Member information in the Component Safety section on page 2.

1. Check all slip yoke assemblies to be sure the slip yoke plug is not loose, missing, or damaged. If any of these situations are evident, replacement of the yoke assembly is necessary.

2. Visually inspect for the presence of the grease zerk (nipple) fitting, if applicable, on the slip yoke. Grease zerk (nipple) fittings should not be missing, loose, or fractured.

3. If a grease zerk (nipple) fitting is loose, tighten it to required specifications. See the Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque table on page 26.

4. If a grease zerk (nipple) fitting is missing or damaged, the slip member assembly must be replaced.

5. Check the slip yoke seals and dust caps. Make sure the seal is properly attached to the slip yoke and is not loose or damaged. If any of these situations are evident, replacement of the slip member and/or seal may be necessary.

6. For an inboard and outboard slip yoke assembly design, check to be sure the slip yoke welch plug is not loose, missing, or damaged.

7. If there is excessive looseness between the mating components, with the presence of vibration, all slip assembly components should be replaced.

Tubing

Please refer to the Tubing information in the Component Safety section on page 2.

1. Check the driveshaft for bent or dented tubing or missing balance weights. If any of these conditions is evident, replacement of the complete driveshaft assembly or tube is necessary.

2. Make certain there is no build-up of foreign material on the driveshaft. If found, build-up should be removed carefully to avoid damaging the driveshaft.

Do not allow solvents to come in contact with seals or greasable areas of the driveshaft assembly. If foreign material cannot be removed without complete assurance that the driveshaft will not be damaged, the complete driveshaft should be replaced with a new OEM driveshaft.
Center Bearings

Please refer to the Center Bearing information in the Component Safety section on page 2.

1. Inspect the center bearing bracket bolts for looseness. If looseness is evident, re-tighten the center bearing bracket bolts. Consult the vehicle manufacturer's documentation for proper bolt torque. Check the alignment of the bracket before tightening the bolt. Bracket should not be skewed more than 3° in relation to the centerline of the driveshaft.

2. Visually inspect the center bearing rubber cushion for damage. Make sure the slingers are not rubbing against the rubber cushion. Verify that the rubber cushion is properly seated in the metal bracket. If any of these conditions are evident, replacement of the center bearing assembly is necessary. Refer to recommendations in the Disassembly and Reassembly on page 16 for proper center bearing replacement procedures.

Midship End Fitting

Please refer to the safety information in the General Safety section and the Midship Nut information in the Component Safety section on page 2.

1. Inspect the center bearing end fitting and bolt hole threads for damage. If the bolt hole threads are damaged, the end fitting must be replaced.

2. Check the center bearing end fitting and fitting nut washer for any looseness. Grasp the end fitting with both hands, and try to move it both vertically and horizontally to feel for looseness. There should NOT be any movement in the center bearing end fitting relative to the midship tube shaft to which it is connected. If any of these conditions are present, the center bearing end fitting and midship tube shaft must be replaced as a pair.

3. Refer to the End Fitting Inspection section on page 5 for proper procedures.

Note: Repeat the same inspection steps for all center bearings within the driveline.
Lubrication

Lack of proper lubrication is among the most common causes of universal joint and slip member problems. Properly sized Spicer universal joints that are adequately lubricated at recommended intervals will normally meet or exceed vehicle operation requirements.

**Note:** Spicer 10 Series™ relube style universal joints contain only enough grease to provide needle roller bearing protection during storage and shipment. It is therefore necessary to completely lubricate each replacement universal joint after assembly into the end fitting.

Inadequate service intervals and failure to properly lubricate the universal joints will cause universal joint failures. Proper lubrication purges all universal joint seals, thus removing abrasive contaminants from the bearing assemblies. Slip members must also be adequately lubricated to prevent slip member failure.

Spicer 10 Series™ Universal Joint and Slip

The Spicer 10 Series™ Driveshafts include 1310 through 1880.

<table>
<thead>
<tr>
<th>City</th>
<th>Highway</th>
<th>Line Haul</th>
<th>On/Off Highway</th>
<th>Off-Highway and Industrial*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5,000/8,000 Miles (8,000/12,000Km) or 3 months (whichever comes first)</td>
<td>10,000/15,000 Miles (16,000/24,000Km) or 3 months (whichever comes first)</td>
<td>10,000/15,000 Miles (16,000/24,000Km) or 30 days (whichever comes first)</td>
<td>5,000/8,000 Miles (8,000/12,000Km) or 3 months (whichever comes first)</td>
<td>500/200 Hrs.</td>
</tr>
</tbody>
</table>

*Grease cycles for off-highway and industrial uses vary depending on the application and operating conditions. In general, to obtain maximum life, lubrication should occur every 500 hours for normal service and every 200 hours for continuous service or severe environmental conditions.

Spicer Driveshaft recommends lubricating with a compatible grease meeting N.L.G.I. Grade 2 specifications with an operating range of +325° F to -10° F (163° C to -23° C). For more information on Spicer Driveshaft lubrication intervals, please refer to Form #3283-SDD.

- **City** is defined as all applications requiring a minimum of 90 percent of operation time within city limits.
- **Highway** is defined as all applications requiring less than 10 percent of operating time on gravel, dirt, or unpaved roads.
- **Line Haul** is defined as 100 percent of operating time on smooth concrete or asphalt.
- **On/Off Highway** is defined as all applications operating primarily on paved roads but requiring more than 10 percent of operating time on gravel, dirt, or unpaved roads.
- **Off-Highway and Industrial** is defined as 100 percent on gravel, dirt, or unpaved roads, or stationary applications.
Lubrication for Universal Joints

Spicer recommends the following requirements be met for any grease used to service most vehicular and industrial applications and all auxiliary driveshaft applications:

- Use a good quality E.P. (extreme pressure) grease (Timken Test Load - 50 lbs. / 23 kg. minimum), and that
- Meets N.L.G.I. (National Lubricating Grease Institute) Grade 2 specifications, and has an
- Operating range of +325° F to -10° F (163° C to -23° C), which is
- Compatible with commonly used multi-purpose greases. For information about grease compatibility, see the Grease Compatibility section below. Consult your local grease source for greases that meet these specifications.

Note: There are instances when special lubrication is required due to original-equipment manufacturer specifications or customer requests. The lubrication recommendations listed in this manual are authorized by Spicer Driveshaft engineering. Any alternate greases or lubrication procedures are the responsibility of the user.

Grease Compatibility

To help reduce the effects of incompatible greases, be sure to thoroughly purge all four bearing seals on each universal joint with the new grease. Purge seals until the fresh grease is visible on the outside of all four bearing seals. It is recommended that all purged grease be wiped clean to prevent discharge into the general environment. Contact your local grease supplier for grease compatibility information.

Lubrication Procedure for Universal Joints

Please refer to the Lubrication information in the Component Safety section.

Required Materials:
- N.L.G.I. Grade-2, E.P. Grease
- Grease gun

May Need If Bearing(s) Will Not Purge:
- C-Clamp
- New straps
- New bolts

1. Use the proper grease to purge all four seals of each universal joint. This flushes abrasive contaminants from each bearing assembly and assures all four bearings are filled. Purge the seals. Spicer seals are made to be purged. Make sure fresh grease is evident at all four universal joint bearing seals.

2. If any of the seals fail to purge, try to push the driveshaft away from the seal that will not purge, while applying grease gun pressure. There will occasionally be one or more bearing assemblies that will not purge.
Lubrication

### Quick Disconnect™ (Half Round) Universal Joints

<table>
<thead>
<tr>
<th>Series</th>
<th>Strap Kit Assemblies</th>
<th>Recommended Bolt Torque</th>
<th>N•m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1310</td>
<td>2-70-18X</td>
<td>13-18 lbs. ft.</td>
<td>17.6 - 24.4</td>
</tr>
<tr>
<td>1330</td>
<td>2-70-18X</td>
<td>13-18 lbs. ft.</td>
<td>17.6 - 24.4</td>
</tr>
<tr>
<td>1350</td>
<td>3-70-18X</td>
<td>30-35 lbs. ft.</td>
<td>40.7 - 46.5</td>
</tr>
<tr>
<td>1410</td>
<td>3-70-18X</td>
<td>30-35 lbs. ft.</td>
<td>40.7 - 46.5</td>
</tr>
<tr>
<td>1480</td>
<td>3-70-28X</td>
<td>45-60 lbs. ft.</td>
<td>61 - 81.3</td>
</tr>
<tr>
<td>1550</td>
<td>3-70-28X</td>
<td>45-60 lbs. ft.</td>
<td>61 - 81.3</td>
</tr>
<tr>
<td>1610</td>
<td>5-70-28X</td>
<td>45-60 lbs. ft.</td>
<td>61 - 81.3</td>
</tr>
<tr>
<td>1710</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
<td>162.7 - 183</td>
</tr>
<tr>
<td>1760</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
<td>162.7 - 183</td>
</tr>
<tr>
<td>1810</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
<td>162.7 - 183</td>
</tr>
</tbody>
</table>

The bolt torque specifications refer to Spicer bearing straps and bearing plates only. If using original-equipment bearing straps and bearing plates, refer to manufacturer’s service manual for proper bolt torque specifications.

**Note:** Unless otherwise noted all recommended bolt torques are with dry threads.

1. If any of the bearing assemblies fail to purge removal of the driveshaft is necessary. See the original-equipment manufacturer for proper driveshaft removal procedures.

2. Place the driveshaft in v-blocks and apply a C-clamp across the half round bearings. Apply grease gun pressure. Completely purge both bearings.

3. If outboard bearings fail to purge, slightly loosen C-clamp and reapply grease gun pressure until both half round bearings purge.

4. After all four bearings purge fresh grease, re-tighten the C-clamp to squeeze out excess grease and wipe clean. This will ease installation of universal joint kit back into yoke. Install universal joint kit in the yoke using new straps and bolts, and torque bolts to the required specifications. Reference bolt torque specifications in the above table.

5. If the bearings still will not purge, complete removal of the universal joint kit is needed to determine the cause of blockage. Refer to original-equipment manufacturer’s service manual for removal procedures.
Bearing Plate (Full Round) Universal Joints

<table>
<thead>
<tr>
<th>Series</th>
<th>Bolt Part Number</th>
<th>Recommended Bolt Torque</th>
<th>N\textbullet m</th>
</tr>
</thead>
<tbody>
<tr>
<td>1610</td>
<td>5-73-709</td>
<td>26-35 lbs. ft.</td>
<td>35.3 - 47.5</td>
</tr>
<tr>
<td>1710</td>
<td>6-73-209</td>
<td>38-48 lbs. ft.</td>
<td>51.5 - 65.1</td>
</tr>
<tr>
<td>1760</td>
<td>6-73-209</td>
<td>38-48 lbs. ft.</td>
<td>51.5 - 65.1</td>
</tr>
<tr>
<td>1810</td>
<td>6-73-209</td>
<td>38-48 lbs. ft.</td>
<td>51.5 - 65.1</td>
</tr>
<tr>
<td>1880</td>
<td>7-73-315</td>
<td>60-70 lbs. ft.</td>
<td>81.3 - 94.9</td>
</tr>
</tbody>
</table>

The bolt torque specifications refer to Spicer bearing straps and bearing plates only. If using original-equipment bearing straps and bearing plates, refer to manufacturer’s service manual for proper bolt torque specifications.

**Note:** Unless otherwise noted all recommended bolt torques are with dry threads.

1. There will occasionally be one or more bearing assembly seals that will not purge. Release seal tension by loosening the bolts holding the bearing assembly that does not purge. It may be necessary to loosen the bearing assembly approximately 1/16” minimum. If loosening it does not cause purging, remove the bearing assembly to determine the cause of blockage.

**Note:** It is essential that all seals be completely purged of old grease and contaminants. If fresh grease can be seen at these seals, the purging process is complete, and the universal joint is properly lubricated.

**Note:** Spalling and/or brinelling can be caused if contaminants (water, air, etc.) are left in the universal joint and/or the bearing seals. Purge old grease thoroughly.

2. Install new bolts, and torque to specifications in the above table.

Snap Ring Universal Joints

1. There will occasionally be one or more bearing assembly seals that will not purge. If any of the seals will not purge, replacement of the universal joint kit is necessary. See the Reassembly - Inboard Slip Style under “Center Bearing Assembly” on page 20 for proper replacement procedures.
Lubrication for Slip Members

Please refer to the Lubrication information in the Component Safety section on page 2.

The grease used for universal joints is satisfactory for slip members. Glidecote® and steel splines both use a high quality E.P. grease meeting N.L.G.I. Grade 2 specifications.

Grease splines at the intervals recommended in the Lubrication Intervals table page 11.

1. Apply grease gun pressure to the grease zerk (nipple) fitting until grease appears at the pressure relief hole in the plug.

2. Now cover the pressure relief hole with your finger and continue to apply pressure until grease appears at the slip yoke seal.

Note: Use caution to prevent seal damage when using high pressure lubrication systems.

Lubrication of Center Bearing Assemblies

Spicer center bearings are lubricated for life. No attempt should be made to add to or change grease within the bearing itself.

Note: For pillow blocks, use original-component manufacturer’s recommended greases and lubrication intervals.
Disassembly and Reassembly

For procedures used in the removal and installation of Spicer Driveshafts from the vehicle, please consult the vehicle manufacturer's service manual. This manual concerns itself only with the disassembly and reassembly of driveshaft components.

Universal Joint

Disassembly - Snap Ring Design
Please refer to the Universal Joint information in the Component Safety section on page 2.

With the driveshaft removed, the following procedure should be followed:

1. Using snap ring pliers, remove the snap rings from the yoke ears.

2. Set the yoke in the arbor press with a piece of tube stock beneath it. Position the yoke with the universal joint grease zerk (nipple) fitting pointing up to prevent interference during disassembly. Place an appropriate push rod on the upper bearing assembly, and press it through to release the lower bearing assembly.

Do not distort yoke ears with excessive force while in the arbor press.

3. If the bearing assembly will not pull out by hand after pressing, grip the bearing cup and pull from the yoke.

4. Place the yoke in the arbor press with the remaining bearing cup face down. Using an appropriate push rod, press on the end of the journal cross trunnion. Continue to press down on the journal cross trunnion until the shoulder of the journal cross makes contact with the inside of the yoke ear.

5. Repeat steps three and four on the remaining bearing assemblies to remove the cross from the yoke.

6. Inspect all yoke cross hole surfaces for damage. Raised metal or fretting can be removed from yoke cross holes with a fine-toothed file and/or emery cloth.
**Reassembly - Snap Ring Design**

Please refer to the Universal Joint information in the Component Safety section on page 2.

1. Using a high quality N.L.G.I., grade 2 extreme pressure (E.P.) grease, apply adequate grease to each bearing cup assembly. Fill all the cavities between the needle rollers, and also apply a liberal coating of grease in the bottom of each bearing cup and on the lip of the seal. Be careful not to get grease on the outside machined surface of the bearing cup.

2. Position the journal cross in the yoke cross holes with the grease zerk (nipple) fitting inward toward the tubing. **Failure to properly position the universal joint may result in the inability to lubricate the universal joint.** If using an arbor press, proceed to Step 3. If using a universal joint installation tool, follow the tool manufacturer’s instructions.

3. Move one end of the journal cross to cause a trunnion to project through the cross hole beyond the outer machined face of the yoke ear. Check the bearings for skewed or dropped needle rollers. Place the bearing cup assembly over the protruding trunnion diameter and align it to the yoke cross hole. Align the yoke in an arbor press with the bearing assembly resting on the base of the press. Cover the yoke ear with a metal plate that has .150” (6.4 mm) minimum thickness. Push the yoke onto the bearing cup assembly until it is flush with the cross hole face.

4. Place a push rod that is smaller than the diameter of the bearing cup assembly under the bearing cup assembly, and continue pressing into the yoke cross hole until a snap ring can be installed.

5. Remove the yoke from the arbor press. Install a snap ring using snap ring pliers.
6. Flip the yoke 180°. Check the bearings for skewed or dropped needle rollers. Place another bearing cup assembly over trunnion diameter, and align it to the yoke cross holes. Align the yoke in arbor press with previously installed bearing cup assembly resting on the base of the press. Place a push rod that is smaller than the bearing cup assembly on top of the bearing cup assembly. Press bearing cup assembly into the yoke cross hole until a snap ring can be installed.

7. Remove the yoke from the arbor press. Install a snap ring using snap ring pliers.

8. Ensure snap rings are seated into the snap ring grooves.

9. Flex the journal cross to make sure it moves freely by hand. Some resistance is acceptable. If it does not move freely, tap the yoke ear as shown.

Disassembly - Bearing Plate Style
Please refer to the Universal Joint information in the Component Safety section on page 2.

With the driveshaft removed, see “Inspection” on page 5 for Bearing Plate (Full Round) Yoke Inspection disassembly procedures.

Reassembly - Bearing Plate Style
Please refer to the Universal Joint information in the Component Safety section on page 2.

1. Remove the cross and bearings from the box and remove all four bearing assemblies. Rotate the cross to inspect for the presence of a positive purging valve in each grease hole of all four trunnions. Then position the cross into the end yoke with its grease fitting in line as near as possible with the slip spline grease fitting. Keep the grease fitting on the inboard side.

2. Using a high quality N.L.G.I., grade 2 extreme pressure (E.P.) grease, apply adequate grease to each bearing cup assembly. Fill all the cavities between the needle rollers, and also apply a liberal coating of grease in the bottom of each bearing cup and on the lip of the seal. Be careful not to get grease on the outside machined surface of the bearing cup.

3. Position one end of the cross to cause a trunnion to project through the hole beyond the outer machined face of the yoke lug.
Disassembly and Reassembly

4. Place a bearing assembly over the trunnion diameter and align it to the cross hole.

5. Holding the trunnion in alignment with the cross hole, install the bearing assembly by hand until it is flush with the face of the end yoke. If the universal joint bearing cap is pressed into place, the bearings and bearing surfaces could be damaged.

6. If the bearing assembly binds in the cross hole, tap it with a soft-faced hammer directly on the center bearing assembly. Do not tap the outer edges of the bearing assembly.

7. When the bearing assembly is completely seated, put the lock plate tab (if used) in place and use the “Grade 8” cap screws furnished with the universal joint and insert them through the cap screw holes in both the lock strap and/or the bearing plate assembly. Thread by hand or with a wrench into the tapped holes in the yoke. Do not torque down the bolts.

Note: The self-locking bolt design for full round yokes uses serrated bolts with lock patch and does not require a lock strap. DO NOT reuse any retaining bolt. If loosening or removal of a bolt is necessary, replace it with a new one.

8. Move the cross laterally to the opposite side and through the cross hole, beyond the machined surface of the yoke lug. Place a bearing assembly over the cross trunnion and slide it into the cross hole, seating the plate to the face of the lug. Thread the bolts by hand or with a wrench into tapped holes in the yoke.

Note: Projecting the trunnion through a cross hole beyond the machined surface of the lug will provide a surface to help align the bearing assembly with the cross hole.

9. For flange yoke applications, install the flange yoke, bearing assemblies, and bolts at this time.

Exact fit of all driveline components is extremely important. The correct parts and clean mating services are essential for safe operation, long life, and good repair.
Center Bearing Assembly

Disassembly - Inboard Slip Style
Please refer to the Center Bearing information in the Component Safety section on page 2.

This information includes procedures for disassembling SAE, DIN, and T-Type Companion Flange / Flange Yoke, Quick Disconnect, and Bearing Plate Styles.

1. Remove the midship nut. Reference the midship nut specification in the Midship Nut Specifications table. Discard the nut. If the washer is damaged, discard and replace it. Otherwise, reuse the washer.

Note: The midship nut can be removed when the coupling shaft is still in the vehicle. For coupling shaft removal, please refer to original-equipment manufacturer’s service document.

2. Remove driveshaft per original-equipment manufacturers instructions, and then place the driveshaft in v-blocks.

3. Mark the counterbore of the coupling shaft end yoke to midship “nose” with a marking stick, paint marker or other legible marking device. This assures proper reassembly of the coupling shaft end yoke in its original phased position.

4. Using a puller, follow the tool manufacturer’s instructions to remove the end fitting. The end fitting has a press fit and should NOT be removed with a hammer. If the end fitting is loose enough to be removed by hand, the entire coupling shaft must be replaced. Remove and discard the slinger from the yoke.

5. Visually inspect the splines of the center bearing end yoke. If the yoke splines are damaged, missing or twisted, the yoke must be replaced. If the yoke hub has cracked, the yoke must be replaced.

6. Visually inspect the midship splines and threads. If the splines or threads are damaged, missing or twisted, replacement of the entire coupling shaft is necessary.
7. On some Spicer center bearing assemblies, a metal retainer spans the outside center bearing bracket. If the metal retainer is present, remove it and discard.

8. Remove and discard the center bearing bracket.

9. Remove and discard the rubber cushion.

10. Using a puller, follow the tool manufacturer’s instructions to remove the bearing assembly from the midship. Discard the center bearing.

11. Inspect the midship for wear on the bearing diameter. If the midship is damaged from a seized bearing, replacement of the entire coupling shaft is necessary.

12. If no damage is apparent, remove the slinger, and proceed to the installation of the center bearing, described in the “Reassembly - Inboard Slip Style” section.
Disassembly and Reassembly

Midship Nut Specifications Table

<table>
<thead>
<tr>
<th>Series</th>
<th>Nut Part Number</th>
<th>Nut Catalog Color</th>
<th>Washer Part Number</th>
<th>Head Size</th>
<th>Nut Torque N•m</th>
<th>lbs. ft.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1310</td>
<td>231781</td>
<td>cadmium plate &amp; wax</td>
<td>230123-12 230123-14</td>
<td>15/16”</td>
<td>136-163</td>
<td>100-120</td>
</tr>
<tr>
<td>1310 (Toyota Only)</td>
<td>10-74-101</td>
<td>cadmium plate &amp; wax</td>
<td>230123-12 230123-14</td>
<td>15/16”</td>
<td>136-163</td>
<td>100-120</td>
</tr>
<tr>
<td>1410</td>
<td>16-74-101</td>
<td>silver</td>
<td>230123-15</td>
<td>1-5/16”</td>
<td>373-440</td>
<td>275-325</td>
</tr>
<tr>
<td>1480</td>
<td>16-74-101</td>
<td>black</td>
<td>230123-15</td>
<td>1-5/16”</td>
<td>542-610</td>
<td>400-450</td>
</tr>
<tr>
<td>1480</td>
<td>16-74-101</td>
<td>silver</td>
<td>230123-15</td>
<td>1-5/16”</td>
<td>373-440</td>
<td>275-352</td>
</tr>
<tr>
<td>1550</td>
<td>231502</td>
<td>black</td>
<td>none</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-530</td>
</tr>
<tr>
<td>1610</td>
<td>231502</td>
<td>black</td>
<td>none</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-525</td>
</tr>
<tr>
<td>1710</td>
<td>20-74-91</td>
<td>black</td>
<td>230123-6</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-525</td>
</tr>
<tr>
<td>1710</td>
<td>231502</td>
<td>black</td>
<td>none</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-525</td>
</tr>
<tr>
<td>1760</td>
<td>20-74-91</td>
<td>black</td>
<td>230123-6</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-525</td>
</tr>
<tr>
<td>1810</td>
<td>20-74-91</td>
<td>black</td>
<td>230123-6</td>
<td>1-5/8”</td>
<td>644-712</td>
<td>475-525</td>
</tr>
</tbody>
</table>

Disassembly - Outboard Slip Style

1. Mark the slip yoke barrel and midship tube shaft with a marking stick, paint marker, or other legible marking device. This ensures proper reassembly of the mating components in their original phased position.

2. Refer to original-equipment manufacturer’s instructions for removal of the coupling shaft.

3. Visually inspect midship tube shaft, looking for wear on spline surface. If splines are damaged, missing or twisted, or Glidecote® is missing, replacement of entire coupling shaft is necessary.

4. On some Spicer center bearing assemblies, a metal retainer spans the outside center bearing bracket. If the metal retainer is present, remove it and discard.

5. Remove and discard the center bearing bracket.

6. Remove and discard the rubber cushion.
7. Using a puller, follow the tool manufacturer's instructions to remove the bearing assembly from the midship. Discard the center bearing.

8. Inspect the midship for wear on the bearing diameter. If the midship is damaged from a seized bearing, replacement of the entire coupling shaft is necessary.

9. If no damage is apparent, remove the slinger and proceed to the installation of the center bearing, described in the 'Reassembly - Outboard Slip Style' section.

Reassembly - Inboard Slip Style

Please refer to the Center Bearing information in the Component Safety section on page 2.

This information pertains to SAE, DIN, and T-Type Companion Flange/Flange Yoke, Quick Disconnect, and Bearing Plate styles.

1. Wipe the bearing surface of the midship tube shaft with a fine emery cloth.

2. Install a new slinger (included in the center bearing replacement parts kit) on the midship tube shaft. Use a section of tubing to avoid damaging the slinger. Make sure the slinger is completely seated against the midship tube shaft shoulder.

3. Before installing the new center bearing assembly, be sure to fill the entire cavity around the bearing with a waterproof lubricant. Enough lubricant must be applied to fill the cavity to the extreme edge of the slinger surrounding the bearing. Lubricants must be waterproof.

Recommended Center Bearing Lubricants

<table>
<thead>
<tr>
<th>Lubricants</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rykon Premium No. 3</td>
<td>Amoco Oil Company</td>
</tr>
<tr>
<td>Amolith 8516</td>
<td>Amoco Oil Company</td>
</tr>
<tr>
<td>Van Talgar No. 4</td>
<td>Exxon Company</td>
</tr>
</tbody>
</table>
4. Carefully align the new center bearing assembly with the ground surface of the midship tube shaft. Install the center bearing onto the midship tube shaft. Minimal force should be necessary to push the center bearing onto the midship tube shaft, provided the shaft and bearing are in alignment.

5. Install the remaining slinger on the end yoke using a section of tubing to avoid damaging the slinger.

6. **Make sure that the phasing marks from driveshaft removal are aligned, and using an installation tool, press the yoke onto the midship tube shaft. Do not strike yoke with hammer or use midship nut to install yoke.**

7. Installation of the driveshaft onto the vehicle can now proceed. Refer to the vehicle manufacturer's documentation for installation procedures. See the Midship Nut information in the Component Safety section on page 2.

**Midship Nut Installation Procedure**

*Only work on components when they are cool to the touch.*

Installing the midship nut onto a threaded midship which is above the ambient temperature will cause the adhesive to cure too rapidly, and the midship nut may not install correctly.

Do not use the midship nut to pull the end fitting onto the midship. This may result in improper seating of the end fitting and will begin the curing of the midship nut adhesive. As a result, the midship nut may not install correctly.

1. Visually inspect the midship washer (if applicable) for flatness, corrosion, or cracks. If the washer is bent, corroded, or cracked, the washer must be replaced.

2. Thoroughly clean midship threads with mineral spirits. Wipe the midship threads dry with a clean, dry rag. **Do not use a wire brush to clean threads.** This may distort the midship threads and result in the midship not being able to properly retain the midship nut.

3. Thoroughly clean the midship washer (if applicable) and the inboard, machined face of the end fitting with mineral spirits. Wipe components with a clean, dry cloth.

4. Do not apply any additional compounds to midship threads, washer (if applicable), or nut. These compounds may interfere with the adhesive that is pre-applied to the midship nut and will be detrimental to its effectiveness. Unacceptable compounds include, but are not limited to:
   - thread lockers, such as Loctite™
   - anti-seizing compounds, such as Never-Seez™
   - lubricants, such as oil, grease, silicone, graphite, or soap.

5. Install the midship washer (if applicable) onto the midship and up against the machined surface of the end fitting.

6. By hand, start the midship nut onto the midship threads until it will no longer spin freely. Use a socket and a torque wrench with a suggested range of 600 lbs. ft. (800 N•m) or equivalent device capable of installing the midship nut to a final torque at a maximum rate of 120 rpm. (Refer to the Midship Nut Specifications table for proper socket size and torque specs.)
Reassembly - Outboard Slip Style

1. Wipe the bearing surface of the midship tube shaft with a fine emery cloth.

2. Install a new slinger (included in the center bearing replacement parts kit) on the midship tube shaft, using a section of tubing to avoid damaging the slinger. Make sure the slinger is completely seated against the midship tube shaft shoulder.

3. When replacing a center bearing assembly, be sure to fill the entire cavity around the bearing with a waterproof lubricant. Enough lubricant must be applied to fill the cavity to the extreme edge of the slinger surrounding the bearing. Refer to the below table.

<table>
<thead>
<tr>
<th>Lubricants</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rykon Premium No. 3</td>
<td>Amoco Oil Company</td>
</tr>
<tr>
<td>Amolith 8516</td>
<td>Amoco Oil Company</td>
</tr>
<tr>
<td>Van Talgar No. 4</td>
<td>Exxon Company</td>
</tr>
</tbody>
</table>

4. Carefully align the new center bearing assembly with the ground surface of the midship tube shaft. Physically push the center bearing onto the midship tube shaft. Minimal force should be necessary to push the center bearing onto the midship tube shaft provided the shaft and bearing are in alignment.

5. Press the remaining slinger on the midship tube shaft using a section of tubing to avoid damaging the slinger.

6. Installation of the driveshaft onto the vehicle can now proceed. Refer to the vehicle manufacturer’s documentation for installation procedures. Ensure phasing marks are aligned on mating components.
Disassembly and Reassembly

Grease Zerk (Nipple) Fittings or Plugs

For procedures used in the removal and installation of Spicer Driveshafts from the vehicle, please consult the vehicle manufacturer’s service manual.

Once the driveshaft has been removed or the defective grease zerk (nipple) fitting or plug is accessible, follow the steps listed in the Disassembly - Universal Joint section on page 16 for replacement. Please refer to the Lubrication information in the Component Safety section page 2.

Universal Joints and Slip Member Assembly

1. Tilt the universal joint or flange yoke and universal joint to allow access to the defective grease zerk (nipple) fitting or plug. Using pliers or an open-ended wrench, turn the grease zerk (nipple) fitting or plug counter-clockwise until it is removed from the journal cross or slip member assembly. Discard the grease zerk (nipple) fitting or plug.

2. Check the threads in the journal or slip member. If threads are damaged, replacement of the universal joint or slip member is necessary. See disassembly procedures for universal joints and slip member in the Disassembly and Reassembly section on page 16.

3. Thoroughly wipe the grease zerk (nipple) fitting or plug threaded hole.

4. Install the new grease zerk (nipple) fitting or plug. Tighten to a minimum 40-55 lbs. in. (4.5 - 6.2 N•m). Continue to turn only until the grease zerk (nipple) fitting is correctly positioned.

Universal Joint Grease Zerk (Nipple) Fitting and Plug Torque

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Minimum Zerk Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>N•m</td>
</tr>
<tr>
<td>500174-1</td>
<td>.250-28 NF Tapered Thread</td>
<td>4.5 - 6.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>lbs. in.</td>
</tr>
<tr>
<td>500168-2</td>
<td>.125-27 PTF</td>
<td>4.5 - 6.2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>40 - 55</td>
</tr>
<tr>
<td><strong>Glossary</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----------------</td>
<td>---------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td><strong>Alignment Bar</strong></td>
<td>A device (gauge) used to check yoke cross hole alignment.</td>
<td></td>
</tr>
<tr>
<td><strong>Ball Yoke</strong></td>
<td>See Tube Yoke.</td>
<td></td>
</tr>
<tr>
<td><strong>Bearing Cross Hole</strong></td>
<td>See Cross Hole.</td>
<td></td>
</tr>
<tr>
<td><strong>Bearing Cup Assembly</strong></td>
<td>Consists of a bearing cup with needle rollers, generally held in place by a seal guard and bearing seal. Sometimes the assembly includes a thrust washer.</td>
<td></td>
</tr>
<tr>
<td><strong>Bearing Cup</strong></td>
<td>A cup-shaped member used as the bearing bore of a bearing cup assembly and for positioning a thrust end of a cross trunnion.</td>
<td></td>
</tr>
<tr>
<td><strong>Bearing Seal</strong></td>
<td>A flexible member of a bearing cup assembly that prevents the escape of grease from or entry of foreign matter into a bearing.</td>
<td></td>
</tr>
<tr>
<td><strong>Bearing Strap</strong></td>
<td>A narrow, stamped metal plate used to retain a bearing cup assembly in a half round end yoke or flange yoke design.</td>
<td></td>
</tr>
<tr>
<td><strong>Center Bearing</strong></td>
<td>Consists of a rolling element bearing isolated in rubber and a bracket configuration for attachment to the vehicle frame.</td>
<td></td>
</tr>
<tr>
<td><strong>Companion Flange</strong></td>
<td>A fixed flange member that attaches a driveshaft to another drivetrain component.</td>
<td></td>
</tr>
<tr>
<td><strong>Coupling Shaft</strong></td>
<td>The coupling member or members of a multiple-piece driveline, which consists of a universal joint, tube, center bearing, and a slip or fixed spline shaft.</td>
<td></td>
</tr>
<tr>
<td><strong>Coupling Shaft Length (Centerline to Centerline)</strong></td>
<td>The distance between the outermost universal joint centers on a driveshaft. On coupling shafts with fixed centers, it is the nominal dimension.</td>
<td></td>
</tr>
<tr>
<td><strong>Cross</strong></td>
<td>See Journal Cross.</td>
<td></td>
</tr>
<tr>
<td><strong>Cross Hole</strong></td>
<td>A through hole in each lug ear of a yoke used to locate a bearing assembly.</td>
<td></td>
</tr>
<tr>
<td><strong>Deflector</strong></td>
<td>See Slinger.</td>
<td></td>
</tr>
<tr>
<td><strong>Driveline</strong></td>
<td>An assembly of one or more coupling shafts and a driveshaft with provisions for axial movement, which transmits torque and/or rotary motion at a fixed or varying angular relationship from one drivetrain component to another.</td>
<td></td>
</tr>
<tr>
<td><strong>Driveshaft</strong></td>
<td>An assembly of one or two universal joints connected to a tubular shaft member, which accommodates axial movement.</td>
<td></td>
</tr>
<tr>
<td><strong>Driveshaft Length (Centerline to Centerline)</strong></td>
<td>The distance between the outermost universal joint centers on a driveshaft. On driveshafts with variable length centers, driveshaft length is usually measured in the compressed or installed lengths.</td>
<td></td>
</tr>
<tr>
<td><strong>Ear</strong></td>
<td>One of two projecting parts of a yoke symmetrically located with respect to the rotation axis of the yoke.</td>
<td></td>
</tr>
<tr>
<td><strong>End Fitting</strong></td>
<td>An end yoke or companion flange (including SAE, DIN, and T-Type styles) that attaches a driveshaft to another drivetrain component.</td>
<td></td>
</tr>
<tr>
<td><strong>End Yoke</strong></td>
<td>A half round yoke that attaches a driveshaft to another drivetrain component.</td>
<td></td>
</tr>
<tr>
<td><strong>Flange Yoke</strong></td>
<td>A full round or half round style yoke that attaches a driveshaft to a companion flange.</td>
<td></td>
</tr>
<tr>
<td><strong>Flinger</strong></td>
<td>See Slinger.</td>
<td></td>
</tr>
<tr>
<td><strong>Glidecote®</strong></td>
<td>The blue, nylon, wear-resistant coating on Spicer yoke shafts and tube shafts.</td>
<td></td>
</tr>
<tr>
<td><strong>Grease Zerk (Nipple) Fitting</strong></td>
<td>The fitting on the shoulder or center of a journal cross or on a greaseable slip spline that allows for lubrication.</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Definition</td>
<td></td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Half Round Cross Hole</td>
<td>A semicircular hole located on the end of each lug ear of some end yoke and flange yoke designs used to locate a bearing cup assembly.</td>
<td></td>
</tr>
<tr>
<td>Inboard Bearing Assembly</td>
<td>Contained in inboard yoke.</td>
<td></td>
</tr>
<tr>
<td>Inboard Yokes</td>
<td>Yokes that make up the ends of a driveshaft or coupling shaft assembly, i.e. tube yokes, slip yokes, yoke shafts, and center bearing end yokes.</td>
<td></td>
</tr>
<tr>
<td>Journal Cross</td>
<td>The core component of a universal joint, which is an intermediate drive member with four equally spaced trunnions in the same plane.</td>
<td></td>
</tr>
<tr>
<td>Lug Ear</td>
<td>See Ear.</td>
<td></td>
</tr>
<tr>
<td>Midship Shaft</td>
<td>A machined element consisting of spline teeth, a pilot for a center bearing, and a piloting hub that attaches to the tube of a coupling shaft assembly.</td>
<td></td>
</tr>
<tr>
<td>Needle Rollers</td>
<td>One of the rolling elements of a bearing cup assembly.</td>
<td></td>
</tr>
<tr>
<td>Nib</td>
<td>See Tang.</td>
<td></td>
</tr>
<tr>
<td>Outboard Bearing Assembly</td>
<td>Contained in an outboard yoke.</td>
<td></td>
</tr>
<tr>
<td>Outboard Yokes</td>
<td>Yokes that are not a part of a driveshaft or coupling shaft assembly, i.e. transmission, axle, transfer case end yokes.</td>
<td></td>
</tr>
<tr>
<td>Phase Angle</td>
<td>The relative rotational position for each yoke on a driveshaft or driveline.</td>
<td></td>
</tr>
<tr>
<td>Pillow Block</td>
<td>Consists usually of a rolling element bearing and a bracket configuration for attachment.</td>
<td></td>
</tr>
<tr>
<td>Pressure Relief Hole</td>
<td>A hole in the welch plug of Spicer slip yokes that allows air to escape from the slip member assembly.</td>
<td></td>
</tr>
<tr>
<td>Purge</td>
<td>The act of flushing old grease and contaminants from universal joints and slip member assemblies with fresh grease.</td>
<td></td>
</tr>
<tr>
<td>Retaining Ring</td>
<td>See Snap Ring.</td>
<td></td>
</tr>
<tr>
<td>Retaining Ring Groove</td>
<td>See Snap Ring Groove.</td>
<td></td>
</tr>
<tr>
<td>Round Bearing Assembly</td>
<td>See Bearing Cup Assembly.</td>
<td></td>
</tr>
<tr>
<td>Seal Guard</td>
<td>A covering member used to protect a bearing seal on the bearing cup assembly.</td>
<td></td>
</tr>
<tr>
<td>Serrated Flange</td>
<td>See T-Flange.</td>
<td></td>
</tr>
<tr>
<td>Shaft Support Bearing</td>
<td>See Center Bearing.</td>
<td></td>
</tr>
<tr>
<td>Slinger</td>
<td>A stamped metal or non-metal ring, which prevents the entry of foreign matter into a center bearing, transmission, axle, or transfer case.</td>
<td></td>
</tr>
<tr>
<td>Slip</td>
<td>The total permissible length of axial travel.</td>
<td></td>
</tr>
<tr>
<td>Slip Yoke</td>
<td>A yoke that accommodates axial movement.</td>
<td></td>
</tr>
<tr>
<td>Slip Yoke Plug</td>
<td>See Weld Plug.</td>
<td></td>
</tr>
<tr>
<td>Slip Yoke Seal</td>
<td>Pop-on or threaded ring that contains a seal that protects the slip member assembly from environmental contaminants and retains grease.</td>
<td></td>
</tr>
<tr>
<td>Snap Ring</td>
<td>A removable member used as a shoulder to retain and position a bearing cup assembly in a yoke cross hole.</td>
<td></td>
</tr>
<tr>
<td>Snap Ring Groove</td>
<td>A groove used to locate a snap ring.</td>
<td></td>
</tr>
<tr>
<td>Spline</td>
<td>A machined element consisting of integral keys (spline teeth) or keyways (spaces) equally spaced around a circle or portion thereof.</td>
<td></td>
</tr>
<tr>
<td>Term</td>
<td>Description</td>
<td></td>
</tr>
<tr>
<td>-----------------------------</td>
<td>---------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Stub Shaft</td>
<td>See Tube Shaft.</td>
<td></td>
</tr>
<tr>
<td>Tang</td>
<td>A nib of metal found on half round end yoke and/or flange yoke style cross holes, used to locate a bearing cup assembly.</td>
<td></td>
</tr>
<tr>
<td>T-Flange</td>
<td>A companion flange and flange yoke design, which has a serrated flange face. Found most often in European applications.</td>
<td></td>
</tr>
<tr>
<td>T-Type Flange</td>
<td>See T-Flange.</td>
<td></td>
</tr>
<tr>
<td>Thrust Washer</td>
<td>A washer found in the bottom of a bearing cup assembly that reduces needle roller friction and bearing heat, and guards against end galling on the journal cross trunnions.</td>
<td></td>
</tr>
<tr>
<td>Tube</td>
<td>The tubular connecting member of a driveshaft. Pipe or piping is not an equivalent.</td>
<td></td>
</tr>
<tr>
<td>Tubing</td>
<td>See Tube.</td>
<td></td>
</tr>
<tr>
<td>Tube O.D.</td>
<td>The outside diameter (O.D.) of a tube.</td>
<td></td>
</tr>
<tr>
<td>Tube Yoke</td>
<td>An inboard yoke with a piloting hub for attachment to a tube or spline sleeve.</td>
<td></td>
</tr>
<tr>
<td>Tube Shaft</td>
<td>A machined element consisting of spline teeth and a piloting hub that attaches to the tube of a driveshaft assembly.</td>
<td></td>
</tr>
<tr>
<td>Trunnion(s)</td>
<td>Any of four projecting journals of a cross.</td>
<td></td>
</tr>
<tr>
<td>Universal Joint</td>
<td>A mechanical device that can transmit torque and/or rotary motion from one shaft to another at fixed or varying angles of intersection of the shaft axes. Usually consisting of a journal cross, grease zerk (nipple) fitting, and four bearing cup assemblies.</td>
<td></td>
</tr>
<tr>
<td>U-Joint</td>
<td>See Universal Joint.</td>
<td></td>
</tr>
<tr>
<td>Welch Plug</td>
<td>A plug in the slip yoke face that seals off one end of the spline opening. Also known as a slip yoke plug.</td>
<td></td>
</tr>
<tr>
<td>Weld Yoke</td>
<td>See Tube Yoke.</td>
<td></td>
</tr>
<tr>
<td>Yoke Lug Ear Cross Hole</td>
<td>See Cross Hole.</td>
<td></td>
</tr>
<tr>
<td>Yoke Shaft</td>
<td>A slip member yoke with a male machined spline used for axial movement.</td>
<td></td>
</tr>
</tbody>
</table>
# Driveline Sizing

Driveline Analysis

## Critical Speed

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Revisions from: 10/06/03

- Formulas simplified to make calculations easier on pages 3-5.
- Joint Kit Attaching Hardware updated.
- Book structure updated.

Revised date: 03/15/04

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* For page references, please refer to the actual document.
Specifying a Spicer Driveline

Driveline Specification Criteria

Prime Factors:
- Net torque input
- Baseline duty cycle
  - On-highway tractor - 80,000 lbs. CGW
- Modifiers (+/- factors)
  - Duty cycle (vocation)
  - Gross Vehicle Weight (GVW/GCW)
  - Rear axle ratio
  - Universal joint working angle

Application Definitions
- Domestic applications - restricted to the continental United States and Canada.
  - On-highway - operation on well-maintained, concrete and asphalt roadways including turnpikes, interstates, and state routes with not more than 10% off-highway operation.
  - Off-highway - operation on unimproved dirt or gravel roads, as well as, poorly maintained paved roads, more than 10% of the time.
  - Line haul - operation on well maintained concrete and asphalt roadways including turnpikes, interstates, and state routes 100% of the time.
- Export applications - outside of the continental United States and Canada.
  Driveline sizing for export applications is based on Maximum Driveshaft Torque only (see “Calculating Maximum Driveshaft Torque (Export Applications)” on page 5).
Calculating Maximum Low Gear Torque

Step 1 - Low Gear Torque Calculation
LGT = T x TLGR x TE x SR x TCR x C

LGT = Maximum Driveshaft Low Gear Torque
T = Net Engine Torque or 95% of the Gross Engine Torque
TLGR = Transmission Low Gear Ratio (forward)*
TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)
SR = Torque Converter Stall Ratio (if applicable)
TCR = Transfer Case Ratio (if applicable)
C = Transfer Case Efficiency (if applicable, 0.95)

* Some applications require deep reduction transmissions for speed-controlled operations such as paving and pouring. In these applications it may be more appropriate to use the second lowest forward transmission ratio to calculate the Maximum Low Gear Torque. To use the second lowest forward gear ratio to calculate LGT, all three of the following conditions must be met:
1. Lowest forward gear ratio numerically greater than 16:1.
2. Split between the lowest forward gear ratio and the second lowest forward gear ratio is greater than 50%.
3. Startability Index must be greater than 25 (see below calculation).

Startability Index Calculation
SI = (T x TR x AR x TCR x 942.4) / (RR x GCW)

SI = Startability Index
T = Engine Clutch Engagement Torque at 800 RPM
TR = Transmission Second Lowest Forward Gear Ratio
AR = Axle Ratio
TCR = Transfer Case Ratio (if applicable)
RR = Tire Rolling Radius (in)
GCW = Maximum Gross Combination Weight (lbs)

Step 2 - Wheel Slip Calculation
WST = (.71 x W x RR) / (11.4 x AR)

WST = Wheel Slip Torque Applied to the Driveshaft
W = Axle Capacity (lbs)
RR = Tire Rolling Radius (in)
AR = Axle Ratio
Step 3 - Gradeability Calculation
Calculate the torque required for 25% gradeability.

Note: For Linehaul applications with 3.10 axle ratio or numerically larger only.

\[ GT = \frac{(.265 \times RR \times GVW)}{(11.4 \times AR)} \]

- \( GT \) = Net Driveline Torque at 25% Gradeability
- \( RR \) = Tire Rolling Radius (in)
- \( GVW \) = Gross Vehicle Weight (lbs)
- \( AR \) = Axle Ratio

Step 4 - Overall Low Gear Ratio Calculation
\[ OLGR = TLGR \times SR \times TCR \]

- \( OLGR \) = Overall Low Gear Ratio
- \( TLGR \) = Transmission Low Gear Ratio
- \( SR \) = Torque Converter Stall Ratio (if applicable)
- \( TCR \) = Transfer Case Ratio (if applicable)

Step 5 - Driveline Series Selection
To select a driveline series:

1. Use the torque determined from Steps 1, 2, and 3 with the overall low gear ratio (OLGR) from Step 4 to find the applicable series for each torque value.
2. Find the appropriate driveline series for SPL or Ten Series using the “Application Guidelines” on page 6 & 7.
3. Use the smallest series for the main driveline series, as determined from Steps 1, 2, and 3.

Note: The selected driveline series can not be more than one series smaller than the series selected from Step 1 (LGT).

Step 6 - Specifying the Interaxle Driveline (if applicable)
To specify the interaxle driveline, use:

1. 60% of the Driveline Series Selection torque from Step 5 and the OLGR from Step 4.
2. Find the appropriate interaxle driveline series for SPL or Ten Series using the “Application Guidelines” on page 6 & 7.

Note: High angle (45°) interaxle driveshafts are available in SPL-170 and 1710 Series only.
Calculating Maximum Driveshaft Torque (Export Applications)

Step 1 - Low Gear Torque Calculation
\[ \text{LGT} = T \times \text{TLGR} \times \text{TE} \times \text{SR} \times \text{TCR} \times C \]

- \( \text{LGT} \) = Maximum Driveshaft Low Gear Torque
- \( T \) = Net Engine Torque or 95\% of the Gross Engine Torque
- \( \text{TLGR} \) = Transmission Low Gear Ratio (forward)
- \( \text{TE} \) = Transmission Efficiency (automatic = 0.8; manual = 0.85)
- \( \text{SR} \) = Torque Converter Stall Ratio (if applicable)
- \( \text{TCR} \) = Transfer Case Ratio (if applicable)
- \( C \) = Transfer Case Efficiency (if applicable, 0.95)

Step 2 - Overall Low Gear Ratio Calculation
\[ \text{OLGR} = \text{TLGR} \times \text{SR} \times \text{TCR} \]

- \( \text{OLGR} \) = Overall Low Gear Ratio
- \( \text{TLGR} \) = Transmission Low Gear Ratio
- \( \text{SR} \) = Torque Converter Stall Ratio (if applicable)
- \( \text{TCR} \) = Transfer Case Ratio (if applicable)

Step 3 - Driveline Series Selection
To select a driveline series:
1. Use the torque determined from Step 1 with the overall low gear ratio (OLGR) from Step 2 to find the applicable series from the appropriate Driveline Sizing graph. See “Application Guidelines” on page 6 & 7.

Step 4 - Specifying the Interaxle Driveline (if applicable)
To specify the interaxle driveline, use:
1. 60\% of the Driveline Series Selection torque from Step 3 and the OLGR from Step 2.
2. Find the appropriate interaxle driveline series for SPL or Ten Series using the “Application Guidelines” on page 6 & 7.

Note: High angle (45°) interaxle driveshafts are available in SPL-170 and 1710 Series only.
Application Guidelines

10 Series Graph

Application Guidelines for Medium and Heavy Duty Trucks

Maximum Net Driveshaft Torque

Low Gear Ratio
Application Guidelines for Medium and Heavy Duty Trucks

Maximum Net Driveshaft Torque

- SPL 55
- SPL 70
- SPL 100
- SPL 140
- SPL 140HD
- SPL 170
- SPL 250
- SPL 250HD

Low Gear Ratio

N\text{m}
\begin{align*}
29,500 \\
22,125 \\
17,000 \\
12,550 \\
10,000 \\
7,730 \\
7,375 \\
5,700 \\
4,066 \\
3,000
\end{align*}

lbf. ft.
\begin{align*}
40,000 \\
30,000 \\
25,000 \\
20,000 \\
17,000 \\
14,000 \\
10,000 \\
7,730 \\
5,700 \\
3,000
\end{align*}
Critical Speed

Critical speed is defined as: The speed at which the rotational speed of the driveshaft coincides with the natural frequency of the shaft.

Standard Equation

\[ CS = 30 \pi \sqrt[4]{\frac{E \times 386.4 \left(O^2 + I^2 \right)}{P \times L^4 \times 16}} \]

- \( CS \) = Critical Speed
- \( E \) = Modulus of tubing material (psi)
- \( O^* \) = Outside Diameter of Tubing (in)
- \( I^* \) = Inside Diameter of Tubing (in)
- \( P \) = Density of Tubing Material (lbs/in\(^3\))
- \( L \) = Distance Between Journal Cross Centers (in)

* Refer to “Spicer Standard Tube Sizes” on page 19 for tube dimensions.

Material Properties

<table>
<thead>
<tr>
<th>Material</th>
<th>Modulus</th>
<th>Density</th>
<th>( \frac{E}{P} \times 386.4 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>30.00 x 10^6</td>
<td>0.2830</td>
<td>41.0 x 10^9</td>
</tr>
<tr>
<td>Aluminum</td>
<td>10.30 x 10^6</td>
<td>0.0980</td>
<td>39.4 x 10^9</td>
</tr>
</tbody>
</table>

Simplified Equations

Steel:

\[ CS = \frac{4.769 \times 10^6}{L^2} \sqrt[4]{O^2 + I^2} \]

Aluminum:

\[ CS = \frac{4.748 \times 10^6}{L^2} \sqrt[4]{O^2 + I^2} \]

- \( CS \) = Critical Speed
- \( L \) = Distance Between Journal Cross Centers (in)
- \( O \) = Outside Diameter of Tubing (in)
- \( I \) = Inside Diameter of Tubing (in)

Note: The theoretical values and the simplified equation values are the same for the material constants provided.
Adjusted Critical Speed

\[ ACS = TC \times CF \times SF \]

- \( ACS \) = Adjusted Critical Speed
- \( TC \) = Theoretical Critical
- \( CF \) = Correction Factor
- \( SF \) = Safety Factor

Suggested factors for Adjusted Critical Speed:
- Safety Factor = 0.75
- Correction Factor
  - Outboard Slip = 0.92
  - Inboard Slip = 0.75

Maximum Driveshaft Length

Refer to the TMC Recommended Practice RP610A Chart 3 for maximum driveshaft length vs. RPM guidelines.

The general length limitations are as follows:

<table>
<thead>
<tr>
<th>Tube O.D.</th>
<th>Maximum Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.0 in.</td>
<td>60 in.</td>
</tr>
<tr>
<td>3.5 in.</td>
<td>65 in.</td>
</tr>
<tr>
<td>4.0 in.</td>
<td>70 in.</td>
</tr>
<tr>
<td>4.2 in.</td>
<td>72 in.</td>
</tr>
<tr>
<td>4.3 in.</td>
<td>73 in.</td>
</tr>
<tr>
<td>4.5 in.</td>
<td>75 in.</td>
</tr>
<tr>
<td>5.0 in.</td>
<td>80 in.</td>
</tr>
</tbody>
</table>
Center Bearing Mounting

Spicer heavy duty center bearings must be mounted within 3° of perpendicular to the coupling shaft centerline as shown in Figure 1 below OR the center bearing assembly must not operate at a linear offset greater than 1/8" as shown in Figure 2.

Figure 1

Side View

Top View

Figure 2

Side View
Driveline Analysis

Design Criteria
- Torsional Vibration
- Inertial Vibration
- Center Bearing Loading

Torsional and Inertial Excitation

Calculate Joint Angles

To find the true joint angle of each joint, first find the top-view and side-view angles of each joint. The top-view angle of Joint A is equal to 0.67 - 0.00 = 0.67 and the side-view joint angle of Joint A is equal to (-4.0) - (-1.3) = -2.70. By putting the top-view angle (0.67) to the X-axis and the side-view angle (-2.70) to the Y-axis, the true joint angle of Joint A is equal to $2.78 \angle 284.1$ degrees.

Note: The true joint angle is a vector: the 2.78 degrees is the magnitude and the 284.1 degree is the argument. The true joint angles of joints A, B, and C are shown in the following chart.
Calculate Torsional and Inertia Excitation

Calculate the torsional effect:

\[ \Theta_{\text{tor}} = \sqrt{\left(\Theta_1 - \Phi_1\right)^2 + \left(\Theta_2 - (90^\circ - \Phi_2)\right)^2 + \left(\Theta_3 - (90^\circ - \Phi_3)\right)^2} \]

(1) When \( \delta_1 = 0 \) deg, \( \delta_2 = 0 \) deg.

\[ \Theta_{\text{tor}} = \sqrt{(2.78 - 284.1^\circ)^2 + (1.26 - (276.01 - 90^\circ))^2 + (2.58 - 108.29^\circ)^2} \]

\[ = \sqrt{(7.7284 - 151.8^\circ) + (1.5876 - 12.02^\circ) + (6.6564 - 143.42)} \]

\[ = 3.5870^\circ - 72.75^\circ \]

\[ 3.3405 \times 10^6 (2368\text{rpm})^2 (3.5870^\circ)^2 = 241.0154 \frac{\text{rad}}{\text{sec}^2} \]

(2) When \( \delta_1 = 0 \) deg, \( \delta_2 = 90 \) deg.

\[ \Theta_{\text{tor}} = \sqrt{(2.78 - 284.1^\circ)^2 + (1.26 - (276.01 - 90^\circ))^2 + (2.58 - (108.29 - 90^\circ))^2} \]

\[ = \sqrt{(7.7284 - 151.8^\circ) + (1.5876 - 12.02^\circ) + (6.6564 - 36.58)} \]

\[ = 0.80699^\circ - 41.162^\circ \]

\[ 3.3405 \times 10^6 (2368\text{rpm})^2 (0.80699^\circ)^2 = 12.1988 \frac{\text{rad}}{\text{sec}^2} \]

(3) When \( \delta_1 = 90 \) deg, \( \delta_2 = 90 \) deg.

\[ \Theta_{\text{tor}} = \sqrt{(2.78 - 284.1^\circ)^2 + (1.26 - (276.01 - 90 + 90^\circ))^2 + (2.58 - (108.29 - 90 + 90^\circ))^2} \]

\[ = \sqrt{(7.7284 - 151.8^\circ) + (1.5876 - 167.98^\circ) + (6.6564 - 143.42)} \]

\[ = 3.98085^\circ - 74.94^\circ \]

\[ 3.3405 \times 10^6 (2368\text{rpm})^2 (3.98085^\circ)^2 = 296.84 \frac{\text{rad}}{\text{sec}^2} \]
(4) When $\delta_1 = 90\, \text{deg}$, $\delta_2 = 0\, \text{deg}$.

\[
\begin{align*}
&= \sqrt{(2.78\,_{284.1\text{rpm}})^2 + (1.26\,_{(276.01\, - 90\, \text{rpm})}^2 + (2.58\,_{(108.29\, - 90\, \text{rpm})}^2) \\
&= \sqrt{(7.7284\,_{-151.8\text{rpm}}) + (1.5876\,_{-167.98\text{rpm}}) + (6.6564\,_{-36.58\text{rpm}})} \\
&= \sqrt{(3.018639\,_{-179.69\text{rpm}})} \\
&= 1.737423\,_{-89.84\text{rpm}} \\
&= 3.3405\times10^4 \, (2368\text{rpm}) \cdot (1.737423\,)^2 = 56.54 \frac{\text{rad}}{\text{sec}^2}
\end{align*}
\]

Calculate the inertia drive effects:

\[
\Theta_d = \sqrt{2(\Theta_1 \mid \phi_1)^2 + (\Theta_2 \mid (\phi_2 - 90\, \text{rpm} - \delta_0))^2}
\]

(1) When $\delta_1 = 0\, \text{deg}$, $\delta_2 = 0\, \text{deg}$ or $\delta_1 = 0\, \text{deg}$, $\delta_2 = 90\, \text{deg}$.

\[
\begin{align*}
&= \sqrt{2(2.78\,_{284.1\text{rpm}})^2 + (1.26\,_{(276.01\, - 90\, \text{rpm})}^2) \\
&= \sqrt{(15.4568\,_{-151.8\text{rpm}}) + (1.5876\,_{-12.02\text{rpm}})} \\
&= \sqrt{(13.939105\,_{-149.98\text{rpm}})} \\
&= 3.733511\,_{-74.99\text{rpm}} \\
&= 3.3405\times10^4 \, (2368\text{rpm}) \cdot (3.733511\,)^2 = 261.10 \frac{\text{rad}}{\text{sec}^2}
\end{align*}
\]

(2) When $\delta_1 = 90\, \text{deg}$, $\delta_2 = 90\, \text{deg}$ or $\delta_1 = 90\, \text{deg}$, $\delta_2 = 0\, \text{deg}$.

\[
\begin{align*}
&= \sqrt{2(2.78\,_{284.1\text{rpm}})^2 + (1.26\,_{(276.01\, - 90\, \text{rpm})}^2) \\
&= \sqrt{(15.4568\,_{-151.8\text{rpm}}) + (1.5876\,_{-167.98\text{rpm}})} \\
&= \sqrt{(16.987278\,_{-153.29\text{rpm}})} \\
&= 4.12156\,_{-76.64\text{rpm}} \\
&= 3.3405\times10^4 \, (2368\text{rpm}) \cdot (4.12156\,)^2 = 318.19 \frac{\text{rad}}{\text{sec}^2}
\end{align*}
\]

Calculate the inertia coast effects:

\[
\Theta_c = \sqrt{2(\Theta_1 \mid \phi_1)^2 + (\Theta_2 \mid (\phi_2 + 90\, \text{rpm} + \delta_2))^2}
\]

(1) When $\delta_1 = 0\, \text{deg}$, $\delta_2 = 0\, \text{deg}$ or $\delta_1 = 90\, \text{deg}$, $\delta_2 = 0\, \text{deg}$.

\[
\begin{align*}
&= \sqrt{2(2.58\,_{108.29\text{rpm}})^2 + (1.26\,_{(276.01\, + 90\, \text{rpm})}^2) \\
&= \sqrt{(13.3128\,_{-143.42\text{rpm}}) + (1.5876\,_{12.02\text{rpm}})} \\
&= \sqrt{(11.887165\,_{-140.24\text{rpm}})} \\
&= 3.44777\,_{-70.11\text{rpm}} \\
&= 3.3405\times10^4 \, (2368\text{rpm}) \cdot (3.44777\,)^2 = 222.66 \frac{\text{rad}}{\text{sec}^2}
\end{align*}
\]
(2) When $\delta_1 = 0$ deg, $\delta_2 = 90$ deg or $\delta_1 = 90$ deg, $\delta_2 = 90$ deg.

$$
\begin{align*}
\sqrt{2} (2.58 \times 10^8 \text{ rad/sec}^2) + (1.26 \times (276.01 + 90 + 90)) \\
= \sqrt{(13.3128 \times 143.42) + (1.5876 \times 167.98)} \\
= \sqrt{(14.77151 \times 145.98)} \\
= 3.84337 \times 72.99 \\
3.3405 \times 10^6 (2368 \text{ rpm})^2 (3.84337)^2 = 276.69 \text{ rad/sec}^2
\end{align*}
$$

**Note:** The recommended torsional excitation level is 300 rad/sec$^2$ or less. The recommended inertia excitation level is 1000 rad/sec$^2$ or less.

Calculate the torque fluctuations:

The mass moment of inertia of the following items are approximately equal to:

<table>
<thead>
<tr>
<th></th>
<th>lbf-in-sec$^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission</td>
<td>2.33</td>
</tr>
<tr>
<td>Axle</td>
<td>2.53</td>
</tr>
<tr>
<td>1760 Driveshaft</td>
<td>1.3</td>
</tr>
</tbody>
</table>

(1) The torque fluctuation at the axle end is:

$$
T_{\text{axle}} = T_{\text{torsional, axle}} + T_{\text{inertia, drive}} \\
= J_{\text{axle torsional}} + J_{\text{driveshaft drive}} \\
= (2.53)(241.01) + (1.3)(261.10) \\
= 949.18\text{ in-lb} \\
= 79.1\text{ ft-lb}
$$

(2) The torque fluctuation at the transmission end is:

$$
T_{\text{transmission}} = T_{\text{torsional, transmission}} + T_{\text{inertia, coast}} \\
= J_{\text{transmission torsional}} + J_{\text{driveshaft coast}} \\
= (2.33)(241.01) + (1.3)(222.66) \\
= 851.01\text{ in-lb} \\
= 70.92\text{ ft-lb}
$$
Center Bearing Loading

Calculate Static / Dynamic Center Bearing Load

Static

$$\text{Static}$$

$$= \frac{1}{2} \frac{T}{AB-DB} \left\{ \sin a\degree (\phi_1 + 90\degree) + (\tan b\degree \cdot \frac{AB}{BC} \sin b\degree) - (\phi_2 + 90\degree) \right\}$$

$$+ \frac{AB}{BC} \tan c\degree (\phi_1 - 90\degree) \right\}$$

$$= \frac{1 12214x12}{2} \left\{ \sin 2.78\degree (284.1 + 90)\right\}$$

$$+ (\tan 1.26\degree - \frac{40}{44.34} \sin 1.26\degree) (276.01 + 90)\right\}$$

$$+ \frac{40}{44.34} \tan 2.58\degree (108.29 - 90) \right\}$$

$$= 2168.1657 \left\{ 0.0485 (374.1\degree) + 0.0022 (366.01\degree) + 0.0406 (18.29\degree) \right\}$$

$$= 2168.1657 (0.0912 - 15.77\degree)$$

$$= 197.7738 \text{lbs} - 15.77\degree$$

Dynamic

$$= \frac{1}{2} \frac{T}{AB-DB} \left\{ \sin a\degree (90 - \phi_1) + (\tan b\degree + \frac{AB}{BC} \sin b\degree) - (90 - \phi_2) \right\}$$

$$+ \frac{AB}{BC} \tan c\degree (90 - \phi_1 + 2\delta_1 + 2\delta_2) \right\}$$

(1) When $\delta_1 = 0$ deg, $\delta_2 = 0$ deg.

$$= \frac{1 12214x12}{2} \left\{ \sin 2.78\degree (90 - 284.1)\right\}$$

$$+ (\tan 1.26\degree + \frac{40}{44.34} \sin 1.26\degree) (90 - 276.01)\right\}$$

$$+ \frac{40}{44.34} \tan 2.58\degree (90 - 108.29) \right\}$$

$$= 2168.1657 \left\{ 0.0485 (194.1\degree) + 0.0418 (186.01\degree) + 0.0406 (18.29\degree) \right\}$$

$$= 2168.1657 (0.0502 - 176\degree)$$

$$= 108.7635 \text{lbs} - 176\degree$$
(2) When $\delta_1 = 0$ deg, $\delta_2 = 90$ deg.

\[
\frac{112214 \times 12}{2 (40.62)} \sin 2.78^\circ (90 - 284.1)^\circ \\
+ \tan 1.26^\circ \left( \frac{40}{44.34} \sin 1.26^\circ \right) (90 - 276.01)^\circ \\
+ \frac{40}{44.34} \tan 2.58^\circ (90 - 108.29 + 2 \times 90)^\circ \\
= 2168.1657 \{(0.0485 - 194.1^\circ ) + (0.0418 - 186.01^\circ ) + (0.0406 - 161.71^\circ )\} \\
= 2168.1657 (0.1305_{-167.18}^{167.18}) \\
= 282.9240 \text{lbs }_{167.18}
\]

(3) When $\delta_1 = 90$ deg, $\delta_2 = 90$ deg.

\[
\frac{112214 \times 12}{2 (40.62)} \sin 2.78^\circ (90 - 284.1)^\circ \\
+ \tan 1.26^\circ \left( \frac{40}{44.34} \sin 1.26^\circ \right) (90 - 276.01 + 2 \times 90)^\circ \\
+ \frac{40}{44.34} \tan 2.58^\circ (90 - 108.29)^\circ \\
= 2168.1657 \{(0.0485 - 194.1^\circ ) + (0.0418 - 6.01^\circ ) + (0.0406 - 18.29^\circ )\} \\
= 2168.1657 (0.0336_{-9.11}^{9.11}) \\
= 72.8115 \text{lbs }_{-9.11}
\]

(4) When $\delta_1 = 90$ deg, $\delta_2 = 0$ deg.

\[
\frac{112214 \times 12}{2 (40.62)} \sin 2.78^\circ (90 - 284.1)^\circ \\
+ \tan 1.26^\circ \left( \frac{40}{44.34} \sin 1.26^\circ \right) (90 - 276.01 + 2 \times 90)^\circ \\
+ \frac{40}{44.34} \tan 2.58^\circ (90 - 108.29 + 2 \times 90)^\circ \\
= 2168.1657 \{(0.0485 - 194.1^\circ ) + (0.0418 - 6.01^\circ ) + (0.0406 - 18.29^\circ )\} \\
= 2168.1657 (0.0484_{-155.36}^{155.36}) \\
= 105.03326 \text{lbs }_{-155.36}
\]

**Center Bearing Loads**

<table>
<thead>
<tr>
<th>Design</th>
<th>Static Load</th>
<th>Dynamic Load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solid Rubber</td>
<td>500 lbs.</td>
<td>500 lbs.</td>
</tr>
<tr>
<td>Semi-Slotted Rubber</td>
<td>250 lbs.</td>
<td>250 lbs.</td>
</tr>
<tr>
<td>Slotted Rubber</td>
<td>100 lbs.</td>
<td>100 lbs.</td>
</tr>
</tbody>
</table>
Application Form

Company: ___________________________  Contact: ___________________________

Email: ___________________________  Date: ___________________________

Phone: ___________________________  Fax: ___________________________

Vocation: ________________  Vehicle Make: ________________  Vehicle Model: _____________________

Weight - Empty: ___________________  GVW Total: ___________________

   GVW (Front): ___________  GVW (Rear): ___________  GCW: ___________________

Tires - Size: ______________  Make: ______________________  Rolling Radius: ____________________

Engine - Make: ______________  Model: ______________________  Displacement: ___________________

   Net Torque: __________  At Speed: __________  Net H.P.: __________  At Speed: __________

   Gross Torque: __________  At Speed: __________  Gross H.P.: __________  At Speed: __________

   Maximum Operating Speed (including engine over speed): ____________________

Trans - Make: ______________  Model: ______________________

   Ratios - Forward (including overdrive): __________  Reverse: __________

   Torque Converter - Make: ______________  Model: ______________________  Stall Ratio: __________

   Auxiliary - Make: ______________  Model: ______________________  Ratios: __________

   Transfer Case - Make: ______________  Model: ______________________  Ratios: __________

   Torque Split Ratio - Front: __________  Rear: __________

   Axle Make - Front: ______________  Model: ______________________  Ratios: __________

   Make - Front: ______________  Model: ______________________  Ratios: __________

   B_10 Life Expectancy: __________________

   Vehicle Duty Cycle: __________________

   Description of Vehicle Function: _____________________________________________________________

_______________________________________________________________________________________

_______________________________________________________________________________________

_______________________________________________________________________________________

Signed: ___________________________

Title: ___________________________

Spicer Engineer: ____________________  Phone: ___________________________

Email: ___________________________  Fax: ___________________________
## Application Proposal

<table>
<thead>
<tr>
<th>Vehicle Position</th>
<th>Series</th>
<th>Dana Part Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmission to Rear Axle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission to Auxiliary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Auxiliary to Rear Axle</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transmission to Mid Bearing</td>
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<td></td>
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<tr>
<td>Mid Bearing to Rear Axle</td>
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<tr>
<td>Interaxle</td>
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<tr>
<td>Wheel Drive</td>
<td></td>
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</table>

### Vehicle Application Sketch

<table>
<thead>
<tr>
<th>Plan View</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Side View</th>
</tr>
</thead>
</table>

Proposed By: ____________________________
Signed: _____________________________
Title: _____________________________
## Spicer Standard Tube Sizes

<table>
<thead>
<tr>
<th>Series</th>
<th>Tube Size (in)</th>
<th>Dana Part Number</th>
<th>Torque Rating (lbs. ft.)</th>
<th>Tube Jael (lbs. ft.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1610</td>
<td>4.00 x .134</td>
<td>32-30-52</td>
<td>5,700</td>
<td>8,600</td>
</tr>
<tr>
<td>1710</td>
<td>4.00 x .134</td>
<td>32-30-52</td>
<td>7,700</td>
<td>8,600</td>
</tr>
<tr>
<td>1710 HD</td>
<td>4.09 x .180</td>
<td>32-30-72</td>
<td>10,200</td>
<td>13,925</td>
</tr>
<tr>
<td>1760</td>
<td>4.00 x .134</td>
<td>32-30-92</td>
<td>10,200</td>
<td>10,435</td>
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<tr>
<td>1760 HD</td>
<td>4.09 x .180</td>
<td>32-30-72</td>
<td>12,200</td>
<td>13,925</td>
</tr>
<tr>
<td>1810</td>
<td>4.50 x .134</td>
<td>36-30-62</td>
<td>12,200</td>
<td>13,065</td>
</tr>
<tr>
<td>1810 HD</td>
<td>4.59 x .180</td>
<td>36-30-102</td>
<td>16,500</td>
<td>17,935</td>
</tr>
<tr>
<td>SPL 90</td>
<td>4.00 x .095</td>
<td>32-30-12</td>
<td>4,900</td>
<td>6,300</td>
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<tr>
<td>SPL 140</td>
<td>4.21 x .138</td>
<td>100-30-3</td>
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</tr>
<tr>
<td>SPL 140 HD</td>
<td>4.33 x .197</td>
<td>100-30-5</td>
<td>10,325</td>
<td>16,519</td>
</tr>
<tr>
<td>SPL 170</td>
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<td>120-30-3</td>
<td>12,550</td>
<td>13,185</td>
</tr>
<tr>
<td>SPL 170 HD</td>
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<td>120-30-4</td>
<td>12,550</td>
<td>19,617</td>
</tr>
<tr>
<td>SPL 170 I/A</td>
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<td>110-30-5</td>
<td>12,550</td>
<td>19,875</td>
</tr>
<tr>
<td>SPL 250</td>
<td>5.06 x .167</td>
<td>120-30-4</td>
<td>16,225</td>
<td>19,617</td>
</tr>
<tr>
<td>SPL 250 HD</td>
<td>5.12 x .197</td>
<td>120-30-5</td>
<td>18,450</td>
<td>23,555</td>
</tr>
</tbody>
</table>
Joint Life vs. Joint Angle

Angle (degrees)

% of Expected Joint Life
## Charts

### Snap Ring Cross Holes

<table>
<thead>
<tr>
<th>Type</th>
<th>Series</th>
<th>A (mm / in)</th>
<th>B (mm / in)</th>
<th>C* (mm / in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snap Ring</td>
<td>1210</td>
<td>65.0 / 2.56</td>
<td>26.9 / 1.06</td>
<td>79.2 / 3.12</td>
</tr>
<tr>
<td>Construction</td>
<td>1280 / 1310</td>
<td>84.8 / 3.34</td>
<td>26.9 / 1.06</td>
<td>96.8 / 3.81</td>
</tr>
<tr>
<td></td>
<td>1330</td>
<td>95.0 / 3.74</td>
<td>26.9 / 1.06</td>
<td>106.4 / 4.19</td>
</tr>
<tr>
<td></td>
<td>1350</td>
<td>95.0 / 3.74</td>
<td>30.2 / 1.19</td>
<td>108.0 / 4.25</td>
</tr>
<tr>
<td></td>
<td>1410</td>
<td>109.2 / 4.30</td>
<td>30.2 / 1.19</td>
<td>124.0 / 4.88</td>
</tr>
<tr>
<td></td>
<td>1480</td>
<td>109.2 / 4.30</td>
<td>34.8 / 1.37</td>
<td>124.0 / 4.88</td>
</tr>
<tr>
<td></td>
<td>1550</td>
<td>129.0 / 5.08</td>
<td>34.8 / 1.37</td>
<td>144.5 / 5.69</td>
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<tr>
<td></td>
<td>SPL 90</td>
<td>130.6 / 5.14</td>
<td>41.1 / 1.62</td>
<td>149.4 / 5.88</td>
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<tr>
<td></td>
<td>1650</td>
<td>146.8 / 5.78</td>
<td>41.1 / 1.62</td>
<td>165.1 / 6.50</td>
</tr>
</tbody>
</table>

* Swing diameter clears yoke by 1.5 mm / 0.06 in.
## Half Round Cross Holes

<table>
<thead>
<tr>
<th>Type</th>
<th>Series</th>
<th>A (mm / in)</th>
<th>B (mm / in)</th>
<th>C (mm / in)</th>
<th>D (mm / in)</th>
<th>E (mm / in)</th>
<th>F* (mm / in)</th>
<th>G (mm / in)</th>
<th>H</th>
</tr>
</thead>
<tbody>
<tr>
<td>U-bolt</td>
<td>1210</td>
<td>62.0 / 2.44</td>
<td>26.9 / 1.06</td>
<td>56.4 / 2.22</td>
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<td>0.8 / 0.03</td>
<td>87.4 / 3.44</td>
<td>8.4 / 0.33</td>
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<tr>
<td></td>
<td>1280/1310</td>
<td>81.8 / 3.22</td>
<td>26.9 / 1.06</td>
<td>73.9 / 2.91</td>
<td>35.8 / 1.41</td>
<td>0.8 / 0.03</td>
<td>101.6 / 4.00</td>
<td>8.4 / 0.33</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1330</td>
<td>91.9 / 3.62</td>
<td>26.9 / 1.06</td>
<td>84.1 / 3.31</td>
<td>35.8 / 1.41</td>
<td>0.8 / 0.03</td>
<td>115.8 / 4.56</td>
<td>8.4 / 0.33</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1350</td>
<td>91.9 / 3.62</td>
<td>30.2 / 1.19</td>
<td>81.0 / 3.19</td>
<td>42.2 / 1.66</td>
<td>0.8 / 0.03</td>
<td>115.8 / 4.56</td>
<td>9.9 / 0.39</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1410</td>
<td>106.4 / 4.19</td>
<td>30.2 / 1.19</td>
<td>95.2 / 3.75</td>
<td>42.2 / 1.66</td>
<td>0.8 / 0.03</td>
<td>125.5 / 4.94</td>
<td>9.9 / 0.39</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1480</td>
<td>106.4 / 4.19</td>
<td>35.1 / 1.38</td>
<td>93.7 / 3.69</td>
<td>48.5 / 1.91</td>
<td>0.8 / 0.03</td>
<td>134.9 / 5.31</td>
<td>11.7 / 0.46</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>1550</td>
<td>126.2 / 4.97</td>
<td>35.1 / 1.38</td>
<td>113.5 / 4.47</td>
<td>48.5 / 1.91</td>
<td>0.8 / 0.03</td>
<td>152.4 / 6.00</td>
<td>11.7 / 0.46</td>
<td>-</td>
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<tr>
<td>Bearing</td>
<td>1210</td>
<td>62.0 / 2.44</td>
<td>26.9 / 1.06</td>
<td>53.8 / 2.12</td>
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<td></td>
<td>1280/1310</td>
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<td>26.9 / 1.06</td>
<td>73.9 / 2.91</td>
<td>40.1 / 1.58</td>
<td>0.8 / 0.03</td>
<td>101.6 / 4.00</td>
<td>-</td>
<td>0.25 - 28</td>
</tr>
<tr>
<td></td>
<td>1330</td>
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<td>26.9 / 1.06</td>
<td>84.1 / 3.31</td>
<td>40.1 / 1.58</td>
<td>0.8 / 0.03</td>
<td>115.8 / 4.56</td>
<td>-</td>
<td>0.25 - 28</td>
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<td>0.8 / 0.03</td>
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<td>30.2 / 1.19</td>
<td>95.2 / 3.75</td>
<td>45.7 / 1.80</td>
<td>0.8 / 0.03</td>
<td>125.5 / 4.94</td>
<td>-</td>
<td>0.312 - 24</td>
</tr>
<tr>
<td>Hole</td>
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<td>106.4 / 4.19</td>
<td>35.1 / 1.38</td>
<td>93.7 / 3.69</td>
<td>53.8 / 2.12</td>
<td>0.8 / 0.03</td>
<td>134.9 / 5.31</td>
<td>-</td>
<td>0.375 - 24</td>
</tr>
<tr>
<td></td>
<td>1550</td>
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<td>35.1 / 1.38</td>
<td>113.5 / 4.47</td>
<td>53.8 / 2.12</td>
<td>0.8 / 0.03</td>
<td>152.4 / 6.00</td>
<td>-</td>
<td>0.375 - 24</td>
</tr>
<tr>
<td></td>
<td>1610</td>
<td>134.9 / 5.31</td>
<td>47.8 / 1.88</td>
<td>122.2 / 4.81</td>
<td>63.5 / 2.50</td>
<td>9.7 / 0.38</td>
<td>171.4 / 6.75</td>
<td>-</td>
<td>0.375 - 24</td>
</tr>
<tr>
<td></td>
<td>1710</td>
<td>157.2 / 6.19</td>
<td>49.3 / 1.94</td>
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<td>71.4 / 2.81</td>
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<tr>
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<td>1760</td>
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<td>49.3 / 1.94</td>
<td>165.1 / 6.50</td>
<td>71.4 / 2.81</td>
<td>7.9 / 0.31</td>
<td>212.9 / 8.38</td>
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<tr>
<td></td>
<td>1810</td>
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<td>49.3 / 1.94</td>
<td>179.1 / 7.05</td>
<td>71.4 / 2.81</td>
<td>7.9 / 0.31</td>
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<td>0.50 - 20</td>
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<tr>
<td>Bearing</td>
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<td>106.4 / 4.19</td>
<td>30.2 / 1.19</td>
<td>95.2 / 3.75</td>
<td>45.7 / 1.80</td>
<td>0.8 / 0.03</td>
<td>125.5 / 4.94</td>
<td>8.4 / 0.33</td>
<td>-</td>
</tr>
<tr>
<td>Strap</td>
<td>1480</td>
<td>106.4 / 4.19</td>
<td>35.1 / 1.38</td>
<td>93.7 / 3.69</td>
<td>53.8 / 2.12</td>
<td>0.8 / 0.03</td>
<td>134.9 / 5.31</td>
<td>9.9 / 0.39</td>
<td>-</td>
</tr>
<tr>
<td>Thru-Hole</td>
<td>1550</td>
<td>126.2 / 4.97</td>
<td>35.1 / 1.38</td>
<td>113.5 / 4.47</td>
<td>53.8 / 2.12</td>
<td>0.8 / 0.03</td>
<td>152.4 / 6.00</td>
<td>9.9 / 0.39</td>
<td>-</td>
</tr>
</tbody>
</table>

* Swing diameter clears yoke by 1.5 mm / 0.06 in.
## SPL Full Round Cross Holes

* Swing diameter clears yoke by 1.5 mm.

<table>
<thead>
<tr>
<th>Type</th>
<th>Series</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
<th>D * (mm)</th>
<th>E (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL</td>
<td>SPL 140</td>
<td>128</td>
<td>49</td>
<td>32</td>
<td>160</td>
<td>M8 x 1.00</td>
</tr>
<tr>
<td>Full</td>
<td>SPL 170</td>
<td>153</td>
<td>55</td>
<td>32</td>
<td>185</td>
<td>M8 x 1.00</td>
</tr>
<tr>
<td>Round</td>
<td>SPL 250</td>
<td>152</td>
<td>60</td>
<td>32</td>
<td>184</td>
<td>M8 x 1.00</td>
</tr>
</tbody>
</table>
### SPL Half Round Cross Holes

<table>
<thead>
<tr>
<th>Type</th>
<th>Series</th>
<th>A (mm)</th>
<th>B (mm)</th>
<th>C (mm)</th>
<th>D (mm)</th>
<th>E (mm)</th>
<th>F *  (mm)</th>
<th>G (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bearing</td>
<td>SPL 90</td>
<td>126</td>
<td>41</td>
<td>115</td>
<td>59</td>
<td>6</td>
<td>154</td>
<td>0.375 x 24 UNF</td>
</tr>
<tr>
<td>Strap</td>
<td>SPL 140</td>
<td>139</td>
<td>49</td>
<td>113</td>
<td>76</td>
<td>8</td>
<td>164</td>
<td>12 x 1.25</td>
</tr>
<tr>
<td>Tapped</td>
<td>SPL 170</td>
<td>164</td>
<td>55</td>
<td>140</td>
<td>82</td>
<td>8</td>
<td>193</td>
<td>12 x 1.25</td>
</tr>
<tr>
<td>Hole</td>
<td>SPL 250</td>
<td>163</td>
<td>60</td>
<td>135</td>
<td>88</td>
<td>10</td>
<td>193</td>
<td>12 x 1.25</td>
</tr>
</tbody>
</table>
Joint Kit Attaching Hardware and Torque Specifications

U-bolts

<table>
<thead>
<tr>
<th>Series</th>
<th>Spicer Kit No</th>
<th>Assemblies</th>
<th>Recommended Nut Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1210</td>
<td>5-443X</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1310, SPL22</td>
<td>5-153X, 5-785X, SPL22-1X</td>
<td>2-94-28X</td>
<td>14-17 lbs. ft.</td>
</tr>
<tr>
<td>1330, SPL25</td>
<td>5-213X, 5-790X, SPL25-1X</td>
<td>2-94-28X</td>
<td>14-17 lbs. ft.</td>
</tr>
<tr>
<td>1410, SPL36</td>
<td>5-160X, 5-801X, SPL36-1X</td>
<td>3-94-18X</td>
<td>20-24 lbs. ft.</td>
</tr>
<tr>
<td>1480, SPL55</td>
<td>5-188X, 5-803X, SPL55X</td>
<td>3-94-28X</td>
<td>32-37 lbs. ft.</td>
</tr>
<tr>
<td>1550, SPL70</td>
<td>5-155X, 5-808X, SPL70X</td>
<td>3-94-28X</td>
<td>32-37 lbs. ft.</td>
</tr>
</tbody>
</table>

Bearing Strap

⚠️ WARNING: Bearing strap retaining bolts should not be reused.

<table>
<thead>
<tr>
<th>Series</th>
<th>Spicer Kit No</th>
<th>Assemblies</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL90</td>
<td>SPL90-1X</td>
<td>90-70-28X</td>
<td>45-60 lbs. ft.</td>
</tr>
<tr>
<td>SPL100</td>
<td>SPL100X, SPL100-1X</td>
<td>90-70-28X</td>
<td>45-60 lbs. ft.</td>
</tr>
<tr>
<td>1210</td>
<td>5-443X</td>
<td>2-70-18X</td>
<td>13-18 lbs. ft.</td>
</tr>
<tr>
<td>1310, SPL22</td>
<td>5-153X, 5-785X, SPL22-1X</td>
<td>2-70-18X</td>
<td>13-18 lbs. ft.</td>
</tr>
<tr>
<td>1350, SPL30</td>
<td>5-178X, 5-799X, SPL30-1X</td>
<td>3-70-28X</td>
<td>30-35 lbs. ft.</td>
</tr>
<tr>
<td>1410, SPL36</td>
<td>5-160X, 5-801X, SPL36-1X</td>
<td>3-70-28X</td>
<td>30-35 lbs. ft.</td>
</tr>
<tr>
<td>1480, SPL55</td>
<td>5-188X, 5-803X, SPL55X</td>
<td>3-70-28X</td>
<td>30-35 lbs. ft.</td>
</tr>
<tr>
<td>1550, SPL70</td>
<td>5-155X, 5-808X, SPL70X</td>
<td>3-70-28X</td>
<td>30-35 lbs. ft.</td>
</tr>
<tr>
<td>1610</td>
<td>5-438X, 5-674X</td>
<td>5-70-28X</td>
<td>45-60 lbs. ft.</td>
</tr>
<tr>
<td>1710</td>
<td>5-515X, 5-675X</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
</tr>
<tr>
<td>1760</td>
<td>5-469X, 5-677X</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
</tr>
<tr>
<td>1810</td>
<td>5-510X, 5-676X</td>
<td>6.5-70-18X</td>
<td>115-135 lbs. ft.</td>
</tr>
<tr>
<td>3R</td>
<td>5-3147X, 5-795X, SPL25-6X</td>
<td>2-70-48X</td>
<td>30-35 lbs. ft.</td>
</tr>
<tr>
<td>7260</td>
<td>5-1306X, 5-789X, SPL22-8X</td>
<td>2-70-38X</td>
<td>13-18 lbs. ft.</td>
</tr>
</tbody>
</table>
## Cap and Bolts

**WARNING:** Self locking bolts should not be reused.

### Serrated Bolts with Lock Patch / No Lock Strap (Models after Spring 1994)

<table>
<thead>
<tr>
<th>Series</th>
<th>Bolt Part No</th>
<th>Thread Size</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1610</td>
<td>5-73-709</td>
<td>.312-24</td>
<td>26-35 lbs. ft.</td>
</tr>
<tr>
<td>1710</td>
<td>6-73-209</td>
<td>.375-24</td>
<td>38-48 lbs. ft.</td>
</tr>
<tr>
<td>1760</td>
<td>6-73-209</td>
<td>.375-24</td>
<td>38-48 lbs. ft.</td>
</tr>
<tr>
<td>1810</td>
<td>6-73-209</td>
<td>.375-24</td>
<td>38-48 lbs. ft.</td>
</tr>
<tr>
<td>1880</td>
<td>7-73-315</td>
<td>.438-20</td>
<td>60-70 lbs. ft.</td>
</tr>
</tbody>
</table>

### Bolt with Lock Strap (Pre-Spring 1994 Models)

<table>
<thead>
<tr>
<th>Series</th>
<th>Bolt Part No</th>
<th>Thread Size</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>1610</td>
<td>5-73-109</td>
<td>.312-24</td>
<td>26-35 lbs. ft.</td>
</tr>
<tr>
<td>1880</td>
<td>7-73-115</td>
<td>.438-20</td>
<td>60-70 lbs. ft.</td>
</tr>
</tbody>
</table>

### Quick Disconnect (Half Round)

<table>
<thead>
<tr>
<th>Series</th>
<th>Bolt Part No</th>
<th>Thread Size</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL90</td>
<td>6-73-412</td>
<td>.375-24</td>
<td>45-60 lbs. ft.</td>
</tr>
<tr>
<td>1610</td>
<td>6-73-412</td>
<td>.375-24</td>
<td>45-60 lbs. ft.</td>
</tr>
<tr>
<td>1710</td>
<td>8-73-316</td>
<td>.500-20</td>
<td>115-135 lbs. ft.</td>
</tr>
<tr>
<td>1760</td>
<td>8-73-316</td>
<td>.500-20</td>
<td>115-135 lbs. ft.</td>
</tr>
<tr>
<td>1810</td>
<td>8-73-316</td>
<td>.500-20</td>
<td>115-135 lbs. ft.</td>
</tr>
</tbody>
</table>

## Bearing Plate

**WARNING:** Self locking bolts should not be reused.
# Appendix

## Bearing Retainer

![Bearing Retainer Diagram]

<table>
<thead>
<tr>
<th>Series</th>
<th>Spicer Kit No</th>
<th>Retainer Kit No</th>
<th>Bolt Part No</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL140</td>
<td>SPL140X</td>
<td>140-70-18X</td>
<td>12-73-125M</td>
<td>100-102 lbs. ft.</td>
</tr>
<tr>
<td>SPL170</td>
<td>SPL170X</td>
<td>170-70-18X</td>
<td>12-73-125M</td>
<td>100-102 lbs. ft.</td>
</tr>
<tr>
<td>SPL250</td>
<td>SPL250X</td>
<td>250-70-18X</td>
<td>12-73-125M</td>
<td>100-102 lbs. ft.</td>
</tr>
</tbody>
</table>

## Spring Tab

![Spring Tab Diagram]

<table>
<thead>
<tr>
<th>Series</th>
<th>Spicer Kit No</th>
<th>Spring Tab Kit No</th>
<th>Bolt Part No</th>
<th>Recommended Bolt Torque</th>
</tr>
</thead>
<tbody>
<tr>
<td>SPL140</td>
<td>SPL140X</td>
<td>211941X</td>
<td>8-73-114M</td>
<td>25-30 lbs. ft.</td>
</tr>
<tr>
<td>SPL170</td>
<td>SPL170X</td>
<td>211941X</td>
<td>8-73-114M</td>
<td>25-30 lbs. ft.</td>
</tr>
<tr>
<td>SPL250</td>
<td>SPL250X</td>
<td>211941X</td>
<td>8-73-114M</td>
<td>25-30 lbs. ft.</td>
</tr>
</tbody>
</table>
General Safety Information

To prevent injury to yourself and/or damage to the equipment:

- Read carefully all owners manuals, service manuals, and/or other instructions.
- Always follow proper procedures and use proper tools and safety equipment.
- Be sure to receive proper training.
- Never work alone while under a vehicle or while repairing or maintaining equipment.
- Always use proper components in applications for which they are approved.
- Be sure to assemble components properly.
- Never use worn-out or damaged components.
- Always block any raised or moving device that may injure a person working on or under a vehicle.
- Never operate the controls of the power take-off or other driven equipment from any position that could result in getting caught in the moving machinery.

**WARNING: ROTATING DRIVESHAFTS**

- Rotating auxiliary driveshafts are dangerous. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.
- Do not go under the vehicle when the engine is running.
- Do not work on or near an exposed shaft when engine is running.
- Shut off engine before working on power take-off or driven equipment.
- Exposed rotating driveshafts must be guarded.

**WARNING: GUARDING AUXILIARY DRIVESHAFTS**

We strongly recommend that a power take-off and a directly mounted pump be used to eliminate the auxiliary driveshaft whenever possible. If an auxiliary driveshaft is used and remains exposed after installation, it is the responsibility of the vehicle designer and PTO installer to install a guard.

**WARNING: USING SET SCREWS**

Auxiliary driveshafts may be installed with either recessed or protruding set screws. If you choose a square head set screw, you should be aware that it will protrude above the hub of the yoke and may be a point where clothes, skin, hair, hands, etc. could be snagged. A socket head set screw, which may not protrude above the hub of the yoke, does not permit the same amount of torquing as does a square head set screw. Also a square head set screw, if used with a lock wire, will prevent loosening of the screw caused by vibration. Regardless of the choice made with respect to a set screw, an exposed rotating auxiliary driveshaft must be guarded.

**WARNING: THIS SYMBOL WARNS OF POSSIBLE PERSONAL INJURY.**
<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Driveshaft Torque</td>
<td>2</td>
</tr>
<tr>
<td>Common Causes of Vibrations</td>
<td>3</td>
</tr>
<tr>
<td>Universal Joint Operating Angles</td>
<td>5</td>
</tr>
<tr>
<td>Eliminating Compound Angle Induced Vibrations</td>
<td>11</td>
</tr>
<tr>
<td>Multiple Shaft Installations</td>
<td>13</td>
</tr>
<tr>
<td>Mounting a Midship-Mounted PTO, Pump, or Auxiliary Transmission</td>
<td>16</td>
</tr>
<tr>
<td>Maximum Safe Operating Speed</td>
<td>18</td>
</tr>
</tbody>
</table>
Introduction

This brochure is intended for:

- Installers who install Spicer driveshafts into an application where the transmission and axle are not in direct line with each other, causing the driveshaft universal joints to operate at an angle.
- Anyone experiencing vibration problems with their application or their vehicle that driveshaft assembly balancing will not correct.
- Truck Equipment Distributors who:
  - Re-work a chassis to change the wheel base.
  - Install a midship mounted power take-off or fire pump.
  - Mount any other PTO-driven device such as a blower, hydraulic pump, or hydraulic motor.

Universal joint failures, as a rule, are of a progressive nature, which, when they occur, generally accelerate rapidly resulting in a mass of melted trunnions and bearings.

Some recognizable signs of universal joint deterioration are:

1. Vibrations - Driver should report to maintenance.
2. Universal joint looseness - End play across bearings.
3. Universal joint discoloration due to excessive heat build-up.
4. Inability to purge all four trunnion seals when re-lubing universal joint.

Items 2) thru 4) should be checked at re-lube cycle and, if detected, reported to the maintenance supervisor for investigation.

Experience with universal joint failures has shown that a significant majority are related to lubricating film breakdown. This may be caused by a lack of lubricant, inadequate lube quality for the application, inadequate initial lubrication, or failure to lubricate properly and often enough.

Failures which are not the result of lubrication film breakdown are associated with the installation, angles and speeds, and manufacturing discrepancies.

Driveshaft failures through torque, fatigue, and bending are associated with overload, excessively high universal joint angles, and drive shaft lengths excessive for operating speeds.
Driveshaft Torque

The following problems are usually a result of torque overloads:
- Twisted driveshaft tube
- Broken yoke shaft, slip yoke, tube yoke, flange yoke, end yoke
- Broken journal cross

How much torque can be generated in your application?

How to Calculate Torque:
\[
LGT = T \times TLGR \times TE \times SR \times TCR \times C
\]
- LGT = Maximum Driveshaft Low Gear Torque
- T = Net Engine Torque or 95% of the Gross Engine Torque
- TLGR = Transmission Low Gear Ratio (forward)*
- TE = Transmission Efficiency (automatic = 0.8; manual = 0.85)
- SR = Torque Converter Stall Ratio (if applicable)
- TCR = Transfer Case Ratio (if applicable)
- C = Transfer Case Efficiency (if applicable, 0.95)

How to Calculate Wheel Slip:
\[
WST = \frac{(.71 \times W \times RR)}{(11.4 \times AR)}
\]
- WST = Wheel Slip Torque Applied to the Driveshaft
- W = Axle Capacity (lbs)
- RR = Tire Rolling Radius (in)
- AR = Axle Ratio

For On Road Applications

Relate the lesser of above to Spicer universal joint ratings. If your torque exceeds the Spicer rating for the universal joint used in your application, switch to a size with a rating compatible to your calculation. However, the series selected cannot be more than one series below the series called for by the LGT calculation.

For Off Road or On-Off Road Applications

Use Low Gear Torque value only to verify or switch to a size with a rating compatible to your calculation.
Common Causes of Vibrations

The three most common causes of driveshaft vibration are: Driveshaft Imbalance, Critical Speed, and Universal Joint Operating Angles.

Driveshaft Imbalance

Eliminate the potential for balance problems before you undertake any other measures.

A driveshaft on a vehicle usually rotates at a higher rate of speed than the tire. For that reason, like tires, driveshafts should be balanced.

Any time you build or rework a driveshaft, make sure it is dynamically balanced at, 3000 RPM for Light Duty or 2500 RPM for Heavy Duty, to the following specifications:

<table>
<thead>
<tr>
<th>Series</th>
<th>Specification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1310, 1330</td>
<td>.375 oz-in total at each end of shaft *</td>
</tr>
<tr>
<td>1350, 1410</td>
<td>.500 oz-in total at each end of shaft *</td>
</tr>
<tr>
<td>1480 - 1880</td>
<td>1.00 oz-in for each ten pounds of driveshaft weight divided proportionally at each end of shaft</td>
</tr>
</tbody>
</table>

* Passenger Car, Light Truck, Van, and SUV only. Industrial, Mobile Off-Highway, PTO, etc. same as 1480 - 1880.

Critical Speed

Every driveshaft has a critical speed. Critical speed is the point at which a rotating driveshaft begins to bow off its normal rotating centerline.

Driveshafts begin to vibrate as they approach critical speed. If they are operated at near critical speed for an extended period, they often fail. This can damage the vehicle and possibly injure persons nearby.

As a driveshaft fabricator or installer, you are responsible for checking the safe operating speed of any driveshaft you fabricate or specify into an application. Make sure it will not operate at a speed higher than Spicer’s recommended safe operating speed. Use Spicer Calculator (P/N J 3253) to determine safe operating speed.

Checking for a Possible Critical Speed Problem

Here is what you must do to make sure you won’t have a critical speed problem:

- Determine the safe operating speed of the driveshaft you want to use in your application. Insert the tube diameter and center-to-center installed length of the shaft you want to use into a Spicer Safe Operating Speed Calculator (P/N. J3253). The calculator will tell you the safe operating speed of the shaft you have chosen.
- Determine the NORMAL and MAXIMUM POSSIBLE operating speed of the driveshaft.
  REMEMBER:
  - On vehicles with a standard transmission that have a 1:1 direct drive high gear and no overdrive, MAXIMUM POSSIBLE driveshaft RPM is the same as the maximum possible ENGINE RPM.
  - On vehicles that have an overdrive transmission, MAXIMUM POSSIBLE driveshaft RPM is higher than maximum possible ENGINE RPM.
Maximum Possible Driveshaft RPM

To calculate the maximum possible driveshaft RPM in vehicles having an overdrive transmission, divide the maximum possible engine RPM by the overdrive ratio. (See examples below.)

<table>
<thead>
<tr>
<th>Example 1:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. engine RPM: 2100</td>
<td></td>
</tr>
<tr>
<td>Overdrive ratio: .79</td>
<td></td>
</tr>
<tr>
<td>2100/.79 = 2658 maximum possible driveshaft RPM</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Example 2:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. engine RPM 6000</td>
<td></td>
</tr>
<tr>
<td>Overdrive ratio: .66</td>
<td></td>
</tr>
<tr>
<td>6000/.66 = 9091 maximum possible driveshaft RPM</td>
<td></td>
</tr>
</tbody>
</table>

Compare the maximum possible driveshaft RPM with the safe operating speed determined from the Safe Operating Speed Calculator. If the maximum possible driveshaft RPM meets or exceeds the safe operating speed determined from the calculator, you must do whatever is required to raise the critical speed of the driveshaft you have chosen for the application.

Sample Specification:

To specify a driveshaft for the application described in Example 1 above, compare the safe operating speed for the driveshaft selected with the maximum possible driveshaft RPM calculated (2658 RPM). Make sure the safe operating speed of the driveshaft is greater than 2658 RPM.

Changing the Safe Operating Speed of a Driveshaft

A driveshaft’s safe operating speed can be raised by increasing its tube diameter or by shortening the installed center-to-center length of the driveshaft. Changing the installed length of a driveshaft will require the use of multiple driveshafts with center bearings.

Important: The critical speed of an assembly can be affected by driveshaft imbalance, improper universal joint operating angles, or improperly phased driveshafts. (A properly phased driveshaft has the in-board yokes of the shaft in line with each other.) Each of the above items will tend to lower the true critical speed from the values shown on the calculator.

Since critical speed can ultimately cause driveshaft failure, it is extremely important to be very precise in all applications.
Universal Joint Operating Angles

Every Universal Joint that Operates at an Angle Creates a Vibration

Universal joint operating angles are probably the most common causes of driveline vibration in vehicles that have been reworked, or in vehicles that have had auxiliary equipment installed.

Universal joint operating angles are a primary source of problems contributing to:

- Vibrations
- Reduced universal joint life
- Problems with other drivetrain components that may include:
  - Transmission gear failures
  - Synchronizer failures
  - Differential problems
  - Premature seal failures in axles, transmissions, pumps, or blowers
  - Premature failure of gears, seals, and shafts in Power Take-Offs

When you rework a chassis or install a new driveshaft in a vehicle, make sure that you follow the basic rules that apply to universal joint operating angles:

**RULE 1:** UNIVERSAL JOINT OPERATING ANGLES AT EACH END OF A DRIVESHAFT SHOULD ALWAYS BE AT LEAST 1 DEGREE.

**RULE 2:** UNIVERSAL JOINT OPERATING ANGLES ON EACH END OF A DRIVESHAFT SHOULD ALWAYS BE EQUAL WITHIN 1 DEGREE OF EACH OTHER (ONE HALF DEGREE FOR MOTOR HOMES AND SHAFTS IN FRONT OF TRANSFER CASE OR AUXILIARY DEVICE).

**RULE 3:** FOR VIRTUAL VIBRATION FREE PERFORMANCE, UNIVERSAL JOINT OPERATING ANGLES SHOULD NOT BE LARGER THAN 3 DEGREES. IF THEY ARE, MAKE SURE THEY DO NOT EXCEED THE MAXIMUM RECOMMENDED ANGLES.

A universal joint operating angle is the angle that occurs at each end of a driveshaft when the output shaft of the transmission and driveshaft and the input shaft of the axle and driveshaft are not in line. (See Fig 1)

The connecting driveshaft operates with an angle at each universal joint. It is that angle that creates a vibration.
Reducing and Canceling Vibration

A key point to remember about universal joint operating angles: To reduce the amount of vibration, the angles on each end of a driveshaft should always be SMALL.

To cancel an angle vibration, the universal joint operating angles need to be EQUAL within 1 degree at each end of a driveshaft. On motor home applications and auxiliary transmission installations, the tolerance is 1/2 degree. (See Fig 2)
Single Plane and Compound Universal Joint Operating Angles

There are two types of universal joint operating angles: Single Plane and Compound.

Single Plane

Single Plane angles occur when the transmission and axle components are in line when viewed from either the top or side, but not both.

Determining the universal joint operating angle in an application where the components are in line when viewed from the top, but not in line when viewed from the side, is as simple as measuring the slope of the components in the side view, and adding or subtracting those slopes to determine the angle. (See Fig. 3)

These angles should be **small** and **equal** within 1 degree.

![Diagram](Image)

**Figure 3**

The most convenient way to determine universal joint angles in the side view is through the use of a Spicer Anglemaster™ or a bubble type protractor.

Using an Anglemaster or a bubble protractor, record inclination angles of drivetrain components. Set Anglemaster or protractor on machined surfaces of engine, transmission, axle, or on machined lugs of transmission and axle yoke(s).

**Note:** Universal joint angles can change significantly in a loaded situation. Therefore, check vehicle loaded and unloaded to achieve the accepted angle cancellation.

**Example:**

<table>
<thead>
<tr>
<th>Component</th>
<th>Angle</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engine-Transmission Output</td>
<td>4°30’ Down (1)</td>
</tr>
<tr>
<td>Main Driveshaft</td>
<td>7°00’ Down (2)</td>
</tr>
<tr>
<td>Input 1st Rear Axle</td>
<td>4°00’ Up (Input Shaft Nose Up) (3)</td>
</tr>
<tr>
<td>Output 1st Rear Axle</td>
<td>4°00’ Down (4)</td>
</tr>
<tr>
<td>Inter-axle Shaft</td>
<td>7°00’ Down (5)</td>
</tr>
<tr>
<td>Input 2nd Rear Axle</td>
<td>4°15’ Up (Pinion Shaft Nose Up) (6)</td>
</tr>
</tbody>
</table>

**Note:** If inclination of driveshaft is opposite connecting component, add angles to obtain the universal joint operating angle.

**Angle a** = (2) - (1) = 7°00’ - 4°30’ = 2°30’ (2.50°)

**Angle b** = (2) - (3) = 7°00’ - 4°00’ = 3°00’ (3.00°)

**Angle c** = (5) - (4) = 7°00’ - 4°00’ = 3°00’ (3.00°)

**Angle d** = (5) - (6) = 7°00’ - 4°15’ = 2°45’ (2.75°)
Determining the universal joint operating angles on a driveshaft that is straight when viewed from the side and offset when viewed from the top requires the use of a special chart (See Angle Chart). In this type of application, the centerlines of the connected components must be parallel when viewed from the top as shown. These angles also should be small and equal within 1 degree. (See Fig. 4)

Measure dimensions 'A' and 'B' shown in figure 4. Use the instructions in the angle chart below to determine the size of the angle.

To reduce the possibility of vibration, keep any offset between connected points to a minimum.

There are two things you can do to always make sure Single Plane angles are SMALL and EQUAL: Make sure the transmission and axle are mounted so their centerlines are parallel when viewed from both the side and the top. Make sure the offset between them is small in both views.

ANGLE CHART
Compound Angles

Compound universal joint operating angles occur when the transmission and axle are not in line when viewed from BOTH the top and side. Their centerlines, however, are parallel in both views. (See Fig. 5)

When you have a compound angle, you have to calculate the ‘True Universal Joint Operating Angle’ of each universal joint. It is the True Universal Joint Operating Angle that must meet the three rules shown on page 5.

Figure 5
**True Universal Joint Operating Angle**

The True Universal Joint Operating Angle, which must be calculated for each end of the shaft with compound angles, is a combination of the universal joint operating angle in the top view, as determined from the chart, and the measured universal joint operating angle in the side view.

To determine the true universal joint operating angle for one end of a shaft, (compound angle $C^\circ$ in the formula shown in Fig. 6) insert the universal joint operating angle measurement obtained in the side view and the universal joint operating angle obtained from the chart into the formula.

\[
C = \sqrt{T^2 + S^2}
\]

- $T = 2.15^\circ$ (A calculated angle)
- $S = 2.5^\circ$ (The measured angle)

\[
C = \sqrt{2.15^2 + 2.5^2} = \sqrt{10.873} = 3.3^\circ
\]

*Figure 6*

Do the same for the other end of the shaft. Compare the resultant calculated universal joint operating angle for each end. They should be EQUAL within 1 degree. If they’re not, the driveshaft will vibrate.
Eliminating Compound Angle Induced Vibrations

Compound universal joint operating angles are one of the most common causes of driveline vibration. To avoid these problems, remember these important points:

- When setting up an application that requires compound universal joint operating angles, always keep the centerlines of the transmission and axle parallel in both views.
- Always keep the offset between their horizontal and vertical centerlines small.

**Figure 7**

*Note:* Centerlines of transmission and axle must be parallel in both top and side views to use this method of determining true universal joint operating angle. Please contact Spicer Driveshaft Engineering if you have an application where the components cannot be installed with their centerlines parallel.

If adjustments must be made to the system:

- Install shims between the axle housing and springs to rotate the axle input yoke to change operating angles.
- Change operating angle on torque arm type suspensions by lengthening or shortening torque arms.
- Raise, lower, or shift side-to-side a pump, blower, or other piece of auxiliary equipment to change operating angles.

*Note:* It is important to remember to keep the centerlines of two components that are connected by a driveshaft parallel in both the top and side views, so the operating angles will ALWAYS be equal.
Angle Size

The magnitude of a vibration created by a universal joint operating angle is proportional to the size of the universal joint operating angle. Spicer Engineers recommend true universal joint operating angles of 3 degrees or less.

Obtain the true universal joint operating angle, as explained above, and if it is greater than 3 degrees, compare it to this chart.

<table>
<thead>
<tr>
<th>Driveshaft RPM</th>
<th>Maximum Operating Angle</th>
<th>Interaxle Parallel</th>
<th>Interaxle Intersecting</th>
</tr>
</thead>
<tbody>
<tr>
<td>5000</td>
<td>3.2°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4500</td>
<td>3.7°</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>4000</td>
<td>4.2°</td>
<td>3.8°</td>
<td>3.8°</td>
</tr>
<tr>
<td>3500</td>
<td>5.0°</td>
<td>4.4°</td>
<td>4.4°</td>
</tr>
<tr>
<td>3000</td>
<td>5.8°</td>
<td>5.1°</td>
<td>4.8°</td>
</tr>
<tr>
<td>2500</td>
<td>7.0°</td>
<td>6.0°</td>
<td>4.8°</td>
</tr>
<tr>
<td>2000</td>
<td>8.7°</td>
<td>6.0°</td>
<td>4.8°</td>
</tr>
<tr>
<td>1500</td>
<td>11.5°</td>
<td>6.0°</td>
<td>4.8°</td>
</tr>
</tbody>
</table>

The angles shown on this chart are the maximum universal joint operating angles recommended by Spicer Engineers and are directly related to the speed of the driveshaft. Any universal joint operating angle greater than 3 degrees will lower universal joint life and may cause a vibration. Remember to check maximum safe driveshaft RPM by using the Spicer Safe Operating Speed Calculator.
Multiple Shaft Installations

Multiple Shaft Set Up Recommendations

In general, multiple shaft installations follow the same guidelines, except there are different recommendations for setting up the driveline:

- For a 2-shaft application, set up the first coupling shaft (sometimes called a jackshaft) so that the universal joint operating angle that occurs at the transmission end is 1 to 1-1/2 degrees. (See Fig. 8)

![](image)

**Figure 8**

- Try to avoid building a compound universal joint operating angle into the first coupling shaft by installing it in line with the transmission.
- If it ends up being compound, make sure the true universal joint operating angle, determined by using the information mentioned earlier, is 1 to 1-1/2 degrees.

Install or tilt the axle so it is mounted on the same angle as the first coupling shaft (the centerlines of the axle and the first coupling shaft will be parallel).

**Note:** BY FOLLOWING THIS PROCEDURE, THE UNIVERSAL JOINT OPERATING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL. (See Fig. 9)
If there is an offset in the installation of the axle, make sure it does not create too large of a compound universal joint operating angle. Whenever possible, mount the axle directly in line with the first coupling shaft (when viewed from the top).

Check the actual universal joint operating angle at the rear of the first coupling shaft. If it is less than 1° and the transmission universal joint operating angle is greater than 1.5°, rotate the end yoke at the center bearing position so that the ears of the yoke are 90° to the ears of the tube yoke on the transmission end of the coupling shaft. (See Fig. 10) As an alternative, rotate the slip yoke on the driveshift 90° if the slip spline has 16 teeth.

**Figure 9**

![Diagram of true angle adjustment](image1)

True angle 1° to 1-1/2°

Adjust the axle to be on the same angle as the first shaft

These angles will automatically be equal

Adjust the center bearing for true angle

**Figure 10**

![Diagram of adjusting angles](image2)

On same angle

Rotate Yoke

If this angle is less than 1°, rotate yoke as shown
On applications having more than two shafts, mount the first coupling shaft as outlined in the preceding example, and each additional coupling shaft at a 1 to 1-1/2 degree universal joint operating angle to the previous coupling shaft.

Install or tilt the axle to the same angle as the last fixed coupling shaft so the centerline of the axle and the last fixed coupling shaft are parallel.

**Note:** THIS ASSURES THE UNIVERSAL JOINT OPERATING ANGLE AT EACH END OF THE LAST SHAFT WILL AUTOMATICALLY BE EQUAL (See Fig. 11).

**Figure 11**
Mounting a Midship-Mounted PTO, Pump, or Auxiliary Transmission

When installing a midship-mounted PTO, auxiliary transmission, or midship-mounted pump into the main driveline of a vehicle, install it at the same angle as the transmission. Keep the offset to a minimum to reduce universal joint operating angles.

**Note:** Do not make the universal joint operating angle less than 1/2 degree.

Before bolting the device in place, check the universal joint operating angles that occur at each end of the driveshaft. They must be 1 to 1-1/2 degrees and they must be equal to within 1/2 degree for this type of application.

If the device ends up being installed in direct line with the transmission, with little or no universal joint operating angle on the joints, raise or lower it so there is enough offset to create the required 1 to 1-1/2 degree universal joint operating angle on each end of the driveshaft. (See Fig. 12)

If there is only one driveshaft between the device and the rear axle, rotate the rear axle (using shims in the appropriate place) so it is the same angle as the device. This makes the universal joint operating angle at each end of the driveshaft equal (See Fig. 13). Check the size of the universal joint operating angles to determine if they meet recommendations.

**Figure 12**

**Figure 13**
If there is more than one driveshaft between the device and the rear axle, install the driveshaft as outlined earlier with a 1 to 1-1/2 degree universal joint operating angle on the input end of each shaft. Then rotate the axle so it is on the same angle as the last fixed shaft. The universal joint operating angle on each end of the last shaft will automatically be equal. (See Fig. 14)

![Diagram of driveshaft installation](image)

**Figure 14**

**Mounting a Remote-Driven Pump, Blower, or Similar Device**

Remote mounted-pumps, blowers, or similar devices are usually driven by a side, top, or bottom-mounted PTO and use an auxiliary driveshaft.

Many times these devices are mounted to the vehicle frame or cross member. The usual method of mounting, where the driven device is mounted parallel with the ground without regard to the mounted angle of the PTO, will produce a vibration that may cause failure of the PTO, pump, blower, or other driven device.

Any remote driven device must be mounted parallel and in line, if possible, with the PTO.

To select the appropriate auxiliary driveshaft for these types of applications, you should consider proper torque, safe operating speed (which is different than the critical speed for tubular driveshafts), and angularity. (See Maximum Safe Operating Speed Chart on page 18).

An auxiliary driveshaft must be capable of transmitting the maximum torque and RPM required by the driven equipment. For most low-torque applications operating at less than 1200 RPM, solid bar-stock constructed driveshafts are adequate. For applications requiring additional torque or RPMs, tubular shafts should be fabricated.
Maximum Safe Operating Speed

<table>
<thead>
<tr>
<th>TUBING</th>
<th>MAXIMUM INSTALLED LENGTH (IN INCHES) FOR GIVEN RPM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diameter &amp; Wall Thickness</td>
<td>Centerline to Centerline of Joints for a Two Joint Assembly or Centerline of Joint to Centerline of Center Bearing for a Joint and Shaft</td>
</tr>
<tr>
<td>W - Welded S - Seamless</td>
<td>RPM - Revolutions Per Minute</td>
</tr>
<tr>
<td>1.750&quot; x .065&quot; W</td>
<td>82&quot; 67&quot; 58&quot; 52&quot; - - - - - -</td>
</tr>
<tr>
<td>1.250&quot; x .095&quot; S</td>
<td>64&quot; 52&quot; 45&quot; 40&quot; 37&quot; 34&quot; 32&quot; - - - -</td>
</tr>
<tr>
<td>2.500&quot; x .083&quot; W</td>
<td>87&quot; 70&quot; 62&quot; 55&quot; 50&quot; 45&quot; 43&quot; 41&quot; 39&quot; 37&quot; 35&quot;</td>
</tr>
<tr>
<td>3.000&quot; x .083&quot; W</td>
<td>- - 85&quot; 76&quot; 70&quot; 64&quot; 60&quot; 57&quot; 54&quot; 51&quot; 49&quot;</td>
</tr>
<tr>
<td>SOLID SHAFT DIAMETER</td>
<td></td>
</tr>
<tr>
<td>.750&quot;</td>
<td>42&quot; 35&quot; 30&quot; 27&quot; 25&quot; - - - - - -</td>
</tr>
<tr>
<td>.812&quot;</td>
<td>44&quot; 36&quot; 31&quot; 28&quot; 26&quot; - - - - - -</td>
</tr>
<tr>
<td>.875&quot;</td>
<td>46&quot; 37&quot; 32&quot; 29&quot; 27&quot; - - - - - -</td>
</tr>
<tr>
<td>1.000&quot;</td>
<td>49&quot; 40&quot; 35&quot; 31&quot; 28&quot; - - - - - -</td>
</tr>
<tr>
<td>1.250&quot;</td>
<td>55&quot; 45&quot; 39&quot; 35&quot; 32&quot; - - - - - -</td>
</tr>
</tbody>
</table>

To prevent premature wear, auxiliary driveshaft breakage, and possible injury to people or equipment, be aware of the critical speed of these types of driveshafts. Critical speed, explained earlier in this guide, is different for these solid shaft and small tube driveshafts.

Refer to the chart above for maximum safe operating speed information on these types of shafts.

If the chart indicates that the critical speed may be a problem, use multiple shafts. Be sure to use support bearings where necessary and set up the true universal joint operating angles as indicated earlier in this guide.

As with all driveshafts, auxiliary driveshafts should be:

- Carefully installed to minimize vibrations caused by incorrect universal joint operating angles
- Capable of absorbing shock loads
- Capable of changing length as needed
- Guarded so as to prevent inadvertent entanglement
Installation Techniques

Special Notes Regarding Auxiliary Driveshafts

**WARNING:** Working on or near an auxiliary driveshaft when the engine is running is extremely dangerous and should be avoided. You can snag clothes, skin, hair, hands, etc. This can cause serious injury or death.

- Shut off engine before working on power take-off or driven equipment.
- Do not go under the vehicle when the engine is running.
- Do not engage or disengage driven equipment by hand from under the vehicle when the engine is running.
- Fasteners should be properly selected and torqued to the manufacturer’s specifications.
- If a setscrew protrudes above the hub of an end yoke, you may want to replace it with a recessed (Allen-type) setscrew.
- If you decide that a recessed setscrew does not have enough holding power for your application and you must use a protruding setscrew, be sure no one can come in contact with the rotating driveshaft or the protruding setscrew.

- **Exposed rotating driveshafts must be guarded!**
- Lubricate auxiliary driveshafts according to manufacturer’s specifications.